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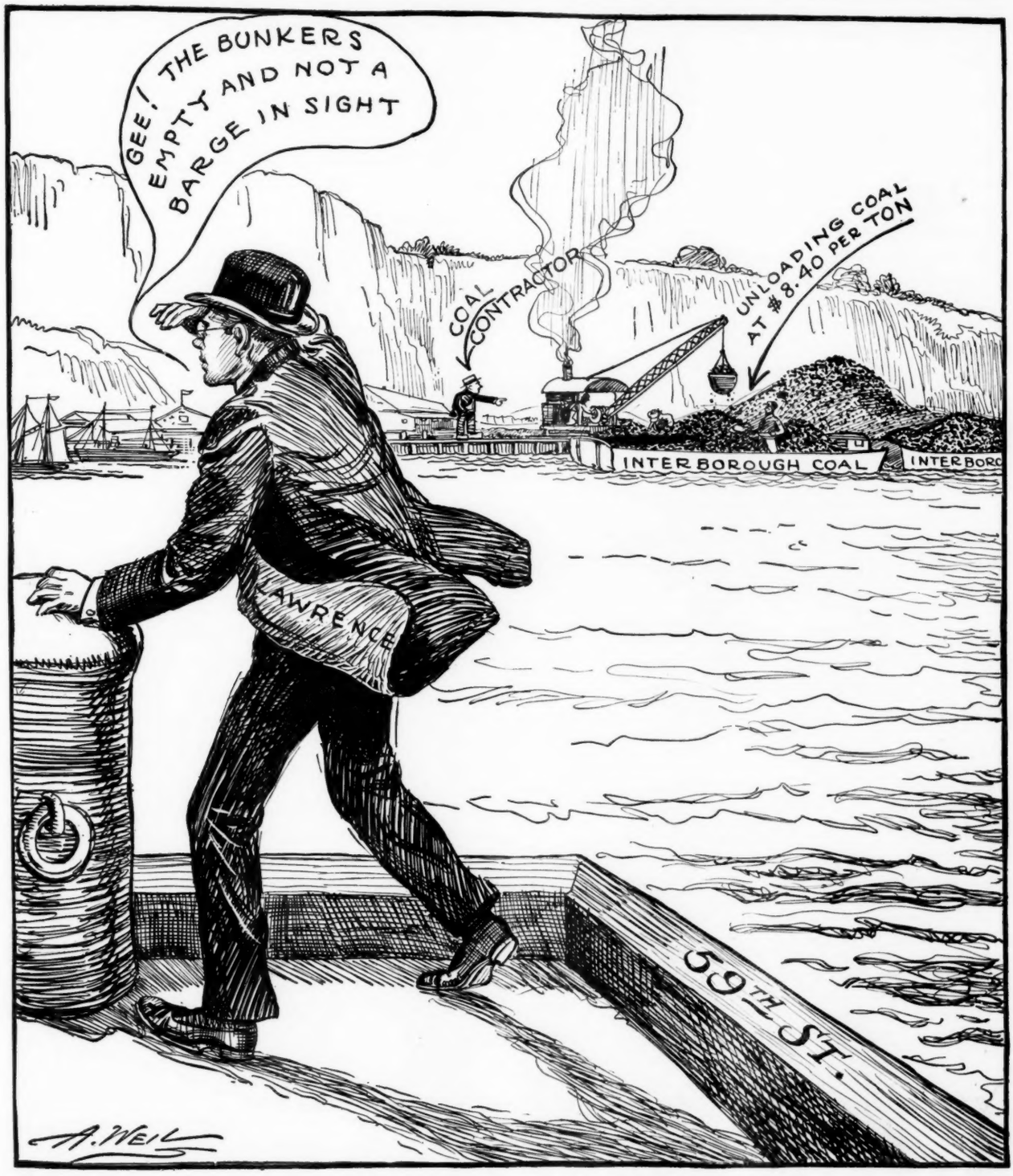

While New Yorkers Walk

Efficiencies of Steam-Turbine Cycles

By C. F. HIRSHFELD
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An interesting study of the possible gains in economy in the modern steam-turbine cycle by increasing the steam pressure and superheat. Ferranti's suggestion of reheating the steam during the early part of its expansion offers a probable advantage of 6 per cent. over the present cycle, but presents numerous mechanical difficulties.

DURING the last decade improvements in prime movers and in the design of power plants have occurred in such rapid succession that the thermal efficiency of such plants has increased at an astonishingly rapid rate. Until quite recently the increasing thermal efficiency more than balanced the gradual increase in the price of fuel, so that the cost of generating a unit of power continuously decreased.

However, the price of fuel has increased so rapidly during the last year that it has, temporarily at least, wiped out a great part of the margin which the increasing thermal efficiency has enabled power engineers to build up, and the situation puts the engineer squarely up against a consideration of what further steps he may take to reduce the effect of rising fuel prices by reducing the quantity of fuel which must be consumed per unit of power generated. A brief consideration of such possibilities may therefore be considered of real and timely interest.

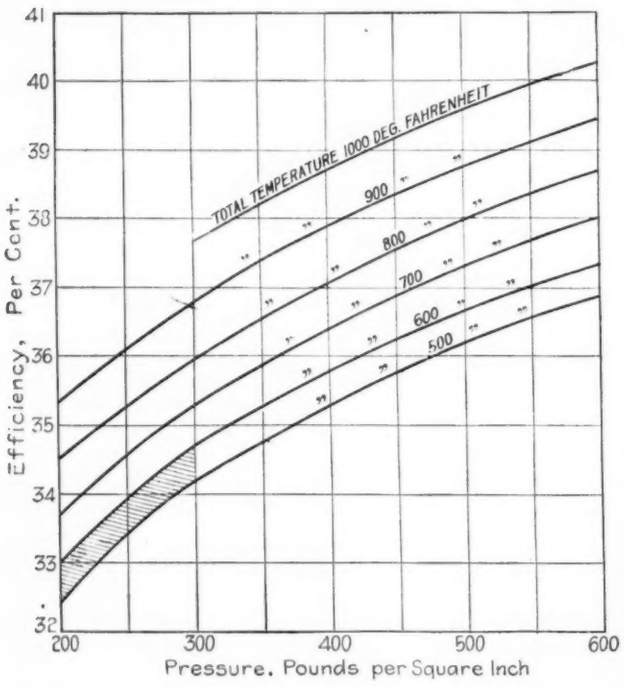


FIG. 1. GAIN IN PRESENT CYCLE BY INCREASING PRESSURE AND TOTAL TEMPERATURE

Further improvements are unquestionably possible in turbines operating under present conditions, and improvements are also possible in boiler-room equipment and practice, but the results now reached in modern plants are so near to those theoretically attainable under the conditions of operation that no improvements of sweeping magnitude may be expected along such lines. It seems probable that the conditions of operation will have to be radically changed if any great reduction in fuel per unit is to be achieved.

Two revolutionary suggestions to this end have been made within the last few years. It was pointed out by Robert Cramer that increasing the initial pressure by several hundred pounds would make it possible to increase materially the theoretical efficiency of present-day cycles, and S. Z. de Ferranti suggested a new form of turbine cycle in which much greater use was made of superheated steam. Both these methods will be considered to such extent as is necessary to indicate their possibilities.

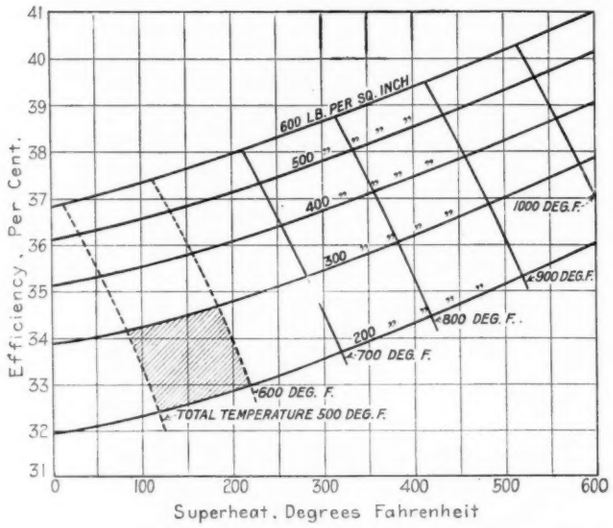


FIG. 2. DATA OF FIG. 1 PLOTTED TO GIVE TOTAL TEMPERATURES, DEGREES SUPERHEAT AND PRESSURE

The highest steam pressures now commonly used with steam turbines are in the neighborhood of 200 to 250 lb. per sq.in., and the highest steam temperatures are about 600 deg. F., corresponding roughly to about 200 deg. of superheat. The highest pressures for which boilers can be built and the highest temperatures which turbine parts can be made to stand are still unknown. The steam tables carry pressures to 600 lb. abs. and total temperatures to about 1000 deg. F. Academically, it is interesting to carry the investigation to these limits, trusting that commercial development will be able to produce the necessary apparatus if the results attainable justify it.

In Fig. 1 are plotted the thermal efficiencies theoretically attainable with steam turbines operating on the cycle now used and expanding steam from various temperatures and pressures to a back pressure of 1 in. of mercury. The small area in the lower left-hand corner which is indicated by hatching covers the range of best practice at the present time. It is obvious

that any increase of pressure or of total temperature causes an increase in the theoretically attainable efficiency.

The same values are given in a different way in Fig. 2. From this figure it is possible to read in terms of total temperatures, degrees superheat and pressure. As before, present practice is indicated by a hatched area.

The limits of design may be set by one or both of two values; that is, pressure and temperature. At the present time it seems probable that boilers and turbines can be built to operate at higher pressures than are now used, but the adaptation of turbine parts to much higher total temperatures is doubtful. Consulting Fig. 2, it is obvious that if 600 deg. F. is taken as the maximum allowable temperature, but it is assumed possible to build for 600 lb. pressure, it is possible to raise the theoretical efficiency from about 33 or 34 per cent. to

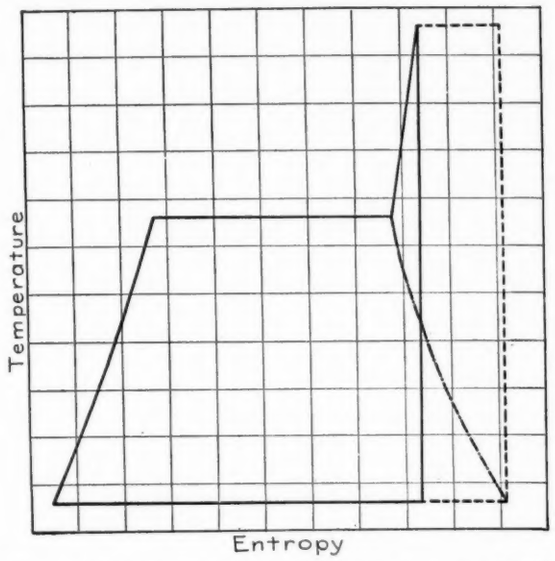


FIG. 3. FERRANTI'S SUGGESTION OF MAKING EARLY PART OF EXPANSION ISOTHERMAL

about 37.5 per cent. If 700 deg. F. is assumed as the limit, the maximum thermal efficiency becomes 38 per cent.

Very efficient modern plants that are theoretically capable of giving an efficiency of about 34 per cent. on the basis here used actually yield an efficiency of about 19 per cent. If it is assumed that the same ratio is possible with higher pressures and superheats, a theoretical efficiency of 38 per cent. would yield an actual efficiency a little better than 21 per cent. and would produce a kilowatt-hour for about 16,000 B.t.u., as against 18,000 to 19,000 B.t.u. at the present time.

While the possibilities of making gains of such magnitude are not to be ignored, it is nevertheless apparent that the maximum conceivable gain is by no means sufficiently large to balance the increase in the price of fuel which occurred during the last year.

It is of interest to notice in Fig. 2 that each hundred-pound increase of pressure is less effective than the preceding one in increasing the efficiency. This fact, coupled with the certainty that the weight and therefore the cost of apparatus must rise rapidly with pressure, indicates that at some point an economic balance will be attained and that an attempt to increase the pressure beyond this point will cause greater increase in capital charges than can be balanced by the increased thermal efficiency attained.

It is always difficult to locate exactly a point of this kind, and it is particularly difficult to do so when the necessary apparatus is not yet developed and when its cost is therefore unknown. However, it seems probable that the best economic balance with coal at such prices as are to be expected in the future will be attained at pressures above 300 lb. and below 400 lb. per sq.in., with total temperatures of between 600 and 700 deg. F. at the turbine. This approximate statement of probable limitations makes it possible to approximate the maximum thermal efficiencies which are to be expected in the near future unless the cycle is materially modified.

The suggestion of Ferranti, previously mentioned, contemplated a radical change of cycle. This is shown in Fig. 3. The full lines indicate the cycle used at the present time, and the dotted lines indicate the changes proposed by Ferranti. Briefly, he suggested adding heat to the steam during the first part of its expansion so as to make that part of the expansion isothermal instead of adiabatic. Such a modification adds materially to the thermal efficiency theoretically attainable with a given maximum pressure and temperature.

Commercially, it would be difficult to add heat to the steam during expansion in any such quantities as would

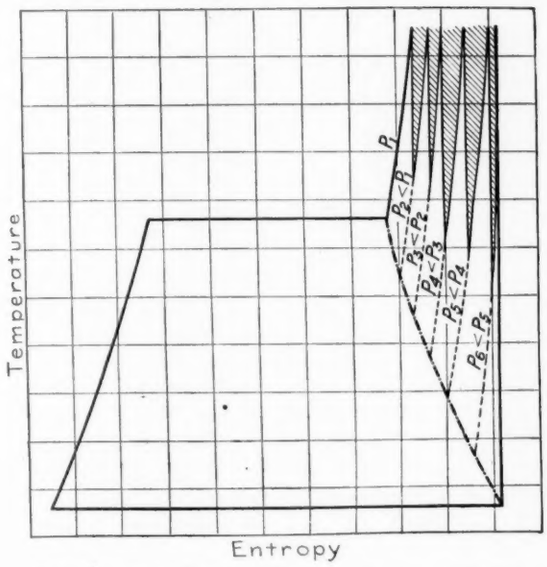


FIG. 4. FERRANTI'S MODIFIED CYCLE USING REHEATERS

be required to produce isothermal expansion and Ferranti therefore contemplated a practical modification of his suggested cycle as shown in Fig. 4. The steam after entering the turbine expands adiabatically to some lower pressure and then enters a reheater in which its temperature is raised to the same value as that at which it entered. It then expands adiabatically again within the turbine and enters a second reheater, and so on. Probably not more than two or, at most, three reheaters could be used commercially.

The reheating method of conducting the cycle is naturally not as efficient as that in which an isothermal expansion is used, because of the loss of the small triangular work areas indicated at the top of the cycle in Fig. 4. For this reason further consideration will be

confined to the cycle with pure isothermal expansion, which may be considered the limiting or ideal case of which the others are a less perfect modification.

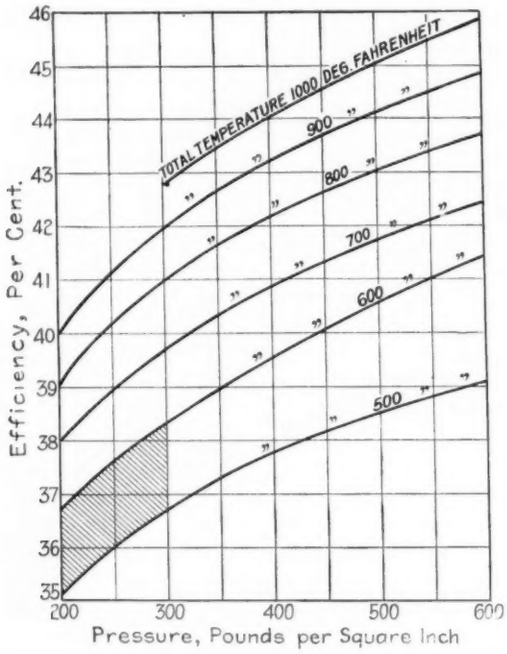


FIG. 5. HIGHER EFFICIENCY POSSIBLE WITH FERRANTI CYCLE

Values of the efficiency of the idealized cycle are shown in Figs. 5 and 6 to coördinates corresponding to Figs. 1 and 2 respectively. Comparison of values with those shown in Figs. 1 and 2 for like conditions of pressure and temperature indicate that what may be called the Ferranti cycle gives higher efficiencies than does that now in use. In a general way the gain is of the order of 10 per cent., a value well worth striving for.

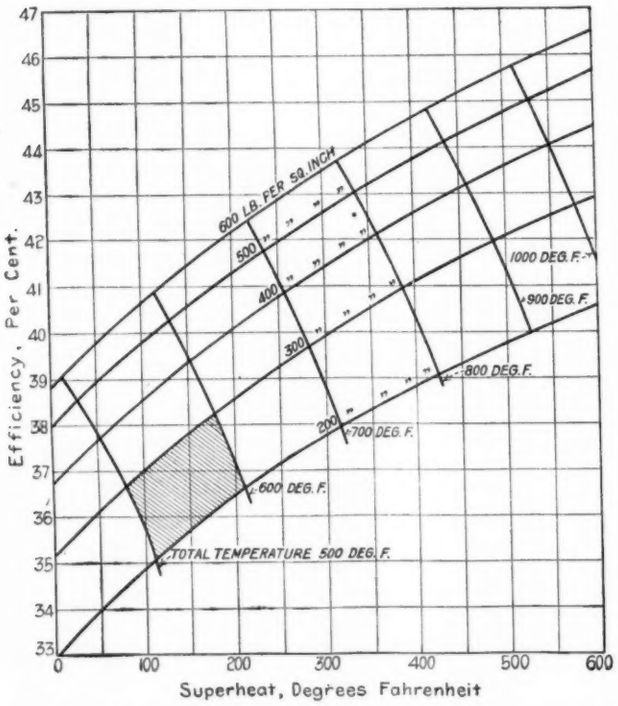


FIG. 6. DATA OF FIG. 5 PLOTTED TO SHOW SUPERHEAT

However, it should be noted that the substitution of reheating as shown in Fig. 4 for the isothermal expansion shown in the idealized cycle in Fig. 3 will somewhat reduce the advantages possessed by this cycle.

At the present time it is impossible to say whether turbines will ever be constructed commercially to operate on this cycle. There are many mechanical difficulties to be overcome, but they do not appear to be of as great magnitude as were those that were met and overcome in the early days of turbine construction. It is therefore conceivable that turbines may be built to operate on the Ferranti cycle or some modification thereof.

If an advantage over the present cycle of the order of 6 per cent. can be attained in actual constructions in place of the 10 per cent. theoretically possible, the 16,000 B.t.u. per kw.-hr. previously mentioned would be reduced to a figure of the order of 15,000. Such a value would correspond roughly to a heat consumption of about 75 to 80 per cent. of that which is customary in most of the large plants of fairly modern construction.

Fires in Transformers

By M. A. Walker

The danger of a fire in an oil-insulated transformer exists not at the bottom of the tank, but at the top. An arc long sustained at the bottom of an oil-filled tank may, however, heat and vaporize the oil, which in turn may burst into flame at its surface. The formation of internal pressures in the transformer tank increases the danger of internal fires.

Operating experience has proved that arcs and fires in a large oil-insulated transformer may give rise to pressures sufficiently great to cause damage to the container. It is now customary to take care of this high pressure in large units, which maybe done in two ways. One is to furnish a means by which high pressures cannot occur, by allowing the gases to escape as they are generated. The second way is to make the transformer tank strong enough mechanically to withstand the maximum pressures that may occur. The user of a transformer is always interested in which these safety measures is adopted in any specific instance, as regards first cost and the performance of the unit.

When a safety valve is installed in a transformer, immediate relief is offered for pressures above the prescribed value. The transformer tank can therefore be made sufficiently strong for normal operation, and the safety valve relied upon to take care of pressures due to abnormal conditions, which occur only infrequently. On the other hand, a transformer capable of withstanding the highest pressures that may exist in times of trouble must have a stronger container than is necessary where a safety valve is employed. Therefore the tank must be of heavier design and more costly construction. On the basis of first cost, the safety valve is obviously preferable; but there is another factor that enters, which has been overlooked in many cases—and with disastrous results. When an explosion occurs in an oil-filled transformer equipped with a safety valve, the gas generated rushes out of the case and with it part of the oil as oil spray or vapor. In some cases the result has been that, not only has the transformer been damaged due to internal trouble, but damage has

been extended to surrounding apparatus and material by fire. It is obviously preferable to restrict the damage as much as possible, for doing so costs less and usually means shortening the time of shutdown. The transformer whose tank is designed to withstand high internal pressures is built to prevent the escape of oil through flanges, crevices, etc. Obviously, such rugged construction and careful workmanship cost more than where a unit is built without taking such precautions—and against an occurrence that may never take place. But should an accident happen, the higher first cost of the more rugged transformer tank may more than pay for itself.

Method of Putting Out Fires Dependent on Circumstances

The question is commonly asked, What is the best way to put out a fire in a large oil-filled transformer? It depends, for there must be considered the safety of the operator as well as saving the burning apparatus, while the liability of the fire spreading must always be borne in mind. Under all circumstances the first thing to do is to interrupt the source of energy. Where emergency oil pits exist for draining off the oil, instructions are often given to open the valve and allow the oil to run out of the transformer. This is the practice of many companies, but is it really the best thing to do? The pressure due to an internal fire is outward; hence when the oxygen of the air contained in the transformer case above the oil level is consumed, the fire cannot be sustained, and must therefore extinguish itself. Under these circumstances there is the probability that only oil will be burned and that the transformer coils will be damaged only at the seat of trouble. Now if the oil is drained off, there is an ever increasing space for the fire to burn in, while the drawing off of the oil will also tend to allow air to enter. If the fire persists as the oil level becomes lower it is reasonable to suppose that the fire may attack the transformer coils, doing costly damage, because oil-soaked insulation when once on fire burns with great tenacity. When draining off the oil, the possibility of its also catching fire cannot be dismissed.

In the opinion of the writer the best way to quench the fire in large oil-filled transformers is to leave them alone, after the energy has been cut off, until they put themselves out. It is certainly the safest and most effective thing to do where the case has been designed for the emergency. Care should be taken not to be too hasty in concluding that the fire has become extinguished. Leave the unit alone, at least until it has commenced to cool off. One is naturally tempted, when the noise and apparent conflagration have subsided, to open the tank and determine the cause of the trouble and the extent of damage. Removing the cover may be dangerous and result in starting the fire again. Authentic cases are on record where operators have been killed when removing transformer covers after a fire, and even after an internal short-circuit. Removal of the cover allows air to enter and enables a spark or smoldering ember to ignite the hot oil (the flash point of most transil oils is about 130 deg. C.), causing such an explosion as to blow off the partly opened cover, throwing burning oil over the operator and setting fire to other apparatus.

There is one method of quenching a fire in transil oil that might be utilized to good advantage in some of the very large oil-filled transformers now in use, although to the writer's knowledge it has never been tried. There are several liquids and gases that are extremely effective for rapidly putting out fire. One of these is carbon tetrachloride; another, carbon monoxide. It would be a simple matter and not an expensive one to equip large oil-filled transformers with an inlet in the top of the case through which a pipe connects to a gas or liquid tank above. One tank could take care of a number of transformers, or each unit could have its own tank, as preferred; the former would be the cheaper and probably would suffice. This tank could be filled with carbon tetrachloride either in liquid or gas form, as considered best for each individual case.

Should a transformer catch fire, the carbon tetrachloride could be turned on by the operator or automatically. It would then run into the transformer and extinguish the fire. Carbon tetrachloride in liquid form would be preferable to the gas, since the former could flow into the transformer under static pressure, whereas the latter would have to be compressed. Moreover, by using carbon tetrachloride, there would be no need to interrupt the energy, since tetrachloride possesses an extremely high dielectric strength. Carbon tetrachloride is a powerful solvent for rubber, but this should be no real drawback, since little rubber is used nowadays in a transformer.

Fires in oil-filled transformers occur much less frequently than might be expected. On the other hand, when they do take place, they may do much damage, depending upon whether or not the damage is restricted or scattered. The possibility of the fire menace is such that it should be borne in mind at all times and be prepared against. The best way to do this appears to be to incase the transformer and its cooling oil in a strong tank that will protect it from fire and pressure and also protect objects outside as well. Another precaution is to cover above the terminal boards, in the transformer, with a good depth of oil, since many of the transformer fires appear to have started close to the surface, due to arcing over between terminals, either by lightning or otherwise. There seems to be little excuse for transformer fires taking place. And there is certainly no excuse for the fire becoming unmanageable and communicating with adjacent apparatus.

Electric-Service Contracts

Where an electric-power company's contract to furnish current to a mercantile establishment at specified rates contained a condition that should the power company grant reduced rates to any other consumer using current under like circumstances, a similar reduction would be made in favor of the mercantile establishment, the latter was entitled to a reduction to the basis of charges made against a realty company for current furnished for an office building, although the power company maintained a substation in the basement of such building. But in determining the equality of rates, the power company is entitled to credit for the rental value of the basement. (New York Supreme Court, Appellate Division, Saks & Co. vs New York Edison Co., 165 New York Supplement, 572.)

Tom Hunter, Hoisting Engineer

By WARREN O. ROGERS

Hunter took me to the Superior compressor plant of the Calumet & Hecla mines, where we found a 7000-hp. engine operating what we were told was the largest compressor that has been built, having a capacity of 27,000 cu.ft. of free air per min. at 65 lb. pressure. A second unit in the same building, but of smaller capacity, was of interest. In the latter instance the transmission of power to the compressors was by gear drive from the engine main crankshaft.

MONDAY morning brought with it a snowstorm that for a time looked like the real thing. However, it cleared off early in the day and permitted of taking pictures to good advantage. The first building visited gave me the shock of my life, for without any previous warning Hunter steered me in through the entrance door of the Superior engine house.

"Whow!" I exclaimed, as we entered the Mackinac compressor room. "This is some baby."

"Surest thing you know," answered Hunter. "You are now looking upon the largest air compressor that has ever been built I understand." See Figs. 1 and 2. "The engine driving these three units is rated at 7000-hp. capacty. It has, as you will see, four cylinders and is a triple-expansion machine, having a 29-in. high-, 51¼-in. intermediate- and two 58-in. low-pressure cylinders, stroke 90 in. The high and intermediate cylinders are placed side by side next to the crankshaft, and the two low-pressure cylinders are in front of the other two cylinders."

"What do they do with all the air these machines compress," I asked, after getting my second wind.

"It is used both for power and for ventilation in the mines. This engine was originally designed to run the compressor by rope drive, a 25-ft. diameter sheave wheel being furnished for that purpose. The idea was never carried out, however, and the compressors were installed to be run with a sort of second-motion drive. The engine is of the Leavitt-Morris design, and as in the general arrangement of this type of engine, the vertical movement of the pistons is transmitted to the horizontal movement of the compressor pistons through a walking beam and a crankshaft.

"You will find that this engine is peculiar in several features. For instance, the piston rods and their extensions connect to a crosshead that is below any other moving part of the engine. From each of the four crossheads a connecting-rod connects to an end of one of the two walking beams and from each beam a main connecting-rod extends to the crank of the main crankshaft."

"I don't get that, Hunter; go a little more into detail."

"All right. Here is the thing in a nutshell. There are two walking beams. The high- and a low-pressure cylinder piston are connected by means of two crossheads and connecting-rods to the two ends of one beam. The intermediate cylinder and the other low-pressure cylinder piston are connected in the same way to the other walking beam. At the top of each beam is a wristpin for the main connecting-rod connecting with the main crank. From the main crank a rod goes to the compressor crosshead and actuates the piston of that unit. I'll make you a sketch tonight." Hunter's sketch is shown in Fig. 8.

"I see, each pair of cylinders work with one walking beam and that makes two crank rods to the main crankshaft."

"Right you are. Those beams are of some size, as the distance from end to end is 12 ft. 6 in. between centers and the main connecting-rod between the beam and the main crank is 20 ft. 6 in. between centers. The cylinders are steam-jacketed and the gridiron type of valves is used."

"That is quite a complicated valve gear," I remarked as I took a photograph of the valve deck on the low-pressure side, Fig. 3.

"It is," replied Hunter. "I believe that it is a feature of this engine. You see there are two horizontal layshafts at the base of the cylinders at the front and back, which carry cams and cutoff gearing for operating the valves. The layshafts are gear-driven from the mainshaft. E. D. Leavitt was the designer of the engine and he believed that the best valve for a steam engine was of the gridiron type, and he always used it except in a few cases."

"What was his idea based upon?" I asked.

Favored Gridiron Valves

"He claimed that a gridiron valve was the only one that would remain tight indefinitely," replied Hunter. "His reason for this was that it has a large working surface and that it has no tendency to cock over and press more on one edge than on the other and that when operated by cams it has a constant travel except, of course, the cutoff valves at early cutoff. He was partial to cams because they gave exact and unchangeable motion to the valve. I don't know that he was so very far wrong either."

"The three Nordberg compressors are two-stage with a 34½-in. high- and 54-in. low-pressure cylinders, stroke 60 in., and each with a capacity of 9000 cu.ft. of free air per minute. Air is compressed to 25 lb. in the low-pressure cylinder and after passing through an intercooler, is compressed to 65 lb. in the high-pressure cylinder."

"Say Hunter, the other day you said that compressing air increased the temperature. What would you get with these pressures?"

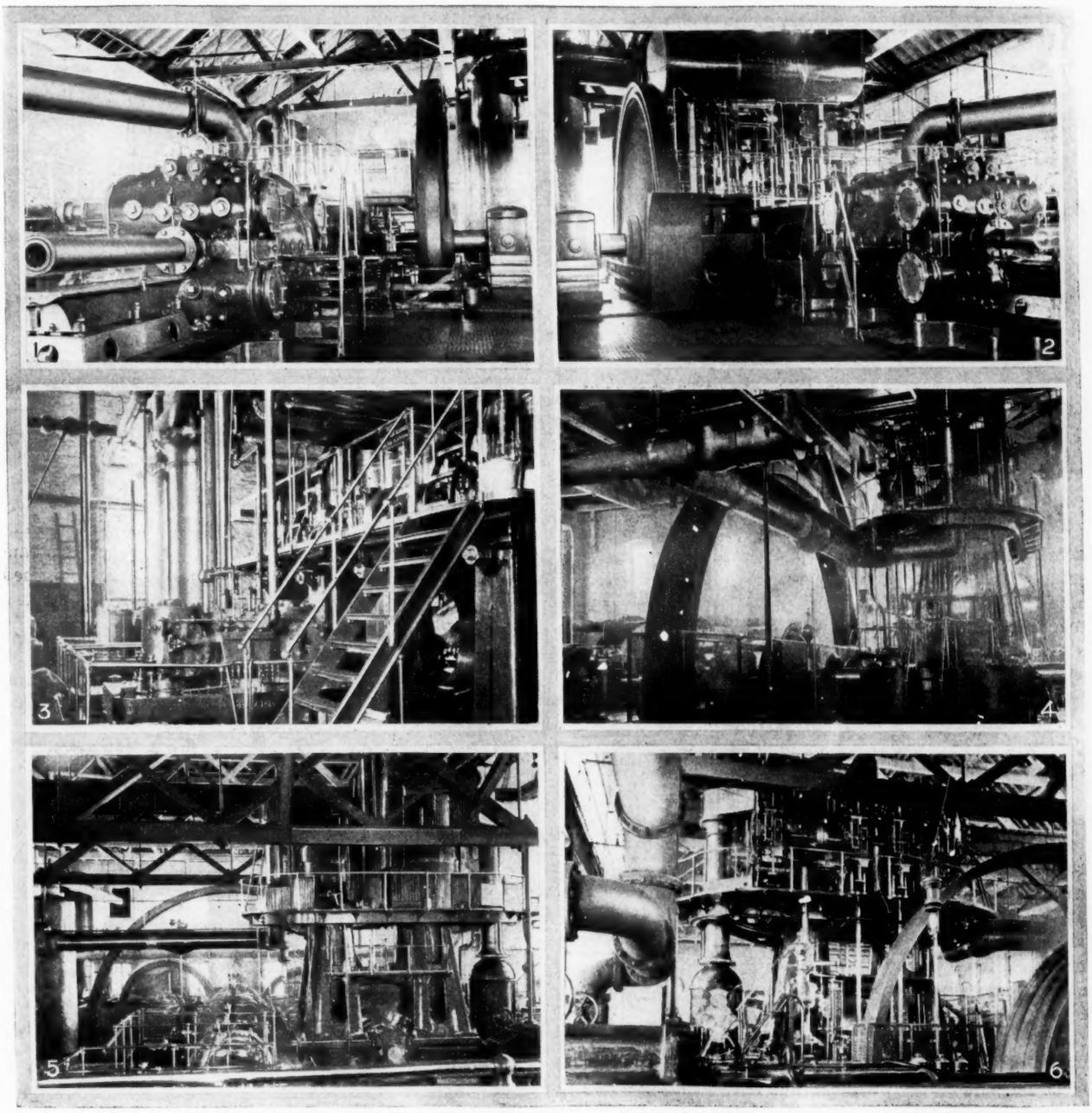
"At 25 lb. pressure the temperature would be 185 deg.," answered Hunter right off the bat, "but it is reduced to 60 deg. in the intercooler and is increased to 180 deg. in the high-pressure cylinder. It is again reduced to 80 deg. in the aftercooler." I found out later that Hunter had observed these temperatures while I was busy with my camera.

"You will notice," continued Hunter, "that the piston rods of these compressors are hollow. The two vertical jet condensers are placed in a well in front of the en-

gine and each has 16 and 38 by 21-in. cylinders, which are rather large for single-cylinder pumps." See Fig. 3.

We were told that this engine was one of 16 of more than 1000-hp. capacity at the company's mines, also that the speed of the engine, 46 r.p.m., was governed by throttling, the air-compressor load being the same and any fluctuation being taken care of by the compressors in the engine room on the other side of a partition.

When we passed into the second engine room, we found another Leavitt-Morris designed engine of the rocker-compound type, with cylinders 40 and 70 by 72 in. This engine the Superior (Figs. 4, 5, 6 and 8) was different from Mackinac in its general design. Although it was fitted with a walking beam, the crossheads were above it and the beam connecting-rods connected to a pin at each end. At the crankshaft side of the engine, the walking-beam pin carried both the crosshead and the main crank. The other end of the main crank rod turned the main crankshaft, which was 19 in. diameter and carried a 32-ft. flywheel. This engine was also fitted with gridiron valves, and the valve gear was positively driven by gears and shafts receiving their motion from the main crankshaft. A belt-driven governor controlled a valve in a vertical cylinder, the piston of which was moved by a hydraulic pressure of about 215 lb. The movement of the piston was transmitted through rods and bell cranks and controlled the cutoff of the steam valves. This was different from the original design, as Hunter later on explained.



FIGS. 1 TO 6. ENGINES AND COMPRESSORS OF THE CALUMET AND HECLA MINES
Figs. 1 and 2—Mackinac triple-expansion engine and compressors. Fig. 3—Engine valve-gear deck and jet condenser. Figs. 4 to 6—Front and side views of the Superior compound engine

A jet-type condenser was attached to the engine bed, making a compact unit on the whole, although a very large one. This engine carried five compound compressors, with a steam pressure of 115 lb. and a vacuum of 25 to 25½ in. These compressors were gear-driven (Fig. 7) from the main crankshaft. That is, the crankshaft carried a 5-ft. spur gear that meshed with a 12-ft. gear mounted on the crankshaft of the compressors.

One thing in particular was noticed in regard to these engines. Although they have been in operation for

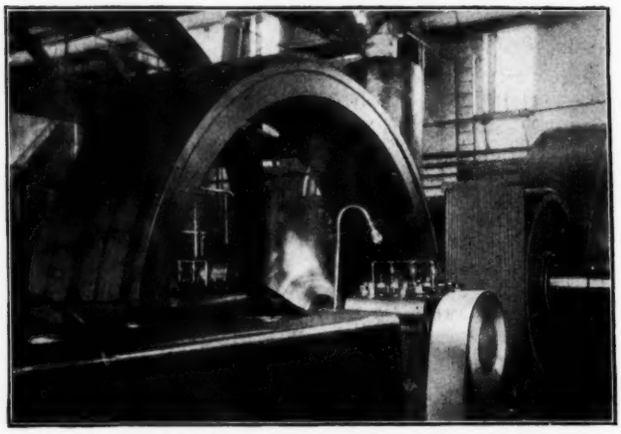


FIG. 7. SPUR GEAR ON CRANKSHAFT DRIVING COMPRESSOR BY MEANS OF A LARGE GEAR

something like 20 years, they operate as smoothly as if they were new. Another thing that was noticeable was the finish of the various parts, which were finely machined and showed a marked contrast to some of the steam machinery made in later years.

"You will find," said Hunter, "that every plant of the C. & H. Co. is kept in apple-pie order, and remarkably clean. Neither you nor anyone else will be allowed to walk on the flooring of some of the hoisting plants, and getting off the rubber matting is a signal for a calldown." I found this to be true, because on two or three occasions later on, while taking photographs, I forgot Hunter's warning and was called to account by the oiler, who has to keep things in order. I have thought since that the cleanly examples set by these men up in northern Michigan might well be put into practice by engineers in many of the manufacturing and large power plants. "This engine has a rather interesting history," continued Hunter as we stood watching its smooth running. "When it was built the camshaft was located near the floor level, and of course the valve rods were pretty long and heavy. The engine was to run at 60 r.p.m., but because of the gear she wouldn't run satisfactorily at that speed, although at 35 r.p.m. gave fair satisfaction. At 60 r.p.m. there was such a hubbub that one had to shout to make the other fellow hear, and at close range at that and breaking of the cutoff cams and levers added to the circus. You see the original high-pressure cutoff mechanism of the engine had a special lever mechanism so as to get a quick valve motion, and this caused part of the trouble.

"They got over the trouble by designing a new valve-gear that was light enough to resist small inertia pressures and the camshaft was raised to about the middle of the cylinders and the valve rocker on the lower valves reached downward and upward from the camshaft for the upper valves. As the outside cams had rolls on opposite sides rotating on pins in forked rockers, there were no overhung pins. The pair of rockers of one cam were connected by links and the shoulder cams were so formed that both rolls always touched the cam. This gave not only a definite and positive motion but a quiet running gear and one that was free from breakdown and repairs. With the new valve-gear in running order the engine was started in the latter part of 1883 and it has been running from 20 to 24 hr. per day ever since.

"The usual place for the crosshead of the Leavitt engines was above the beams, but they have been placed below, as in the case of the Mackinac engine we have just seen. The beams are generally made of two 'flitches,' but sometimes with a single piece. The connecting-rod pins are sometimes overhung from the beam but more often are between the beam flitches. In compound engines the high-pressure cylinder was above one end of the beam and the low-pressure cylinder above the other."

"Hunter, I have noticed that the air compressors at every mine we have been to are for the most part of late design. Now in other industries you will find old types of compressors—so old in some cases that their date of installation is not known. How about it?"

"Why, it is just like this. In a cotton mill back in New England any variation in speed in the spinning room affects the product of the spinning machines, and

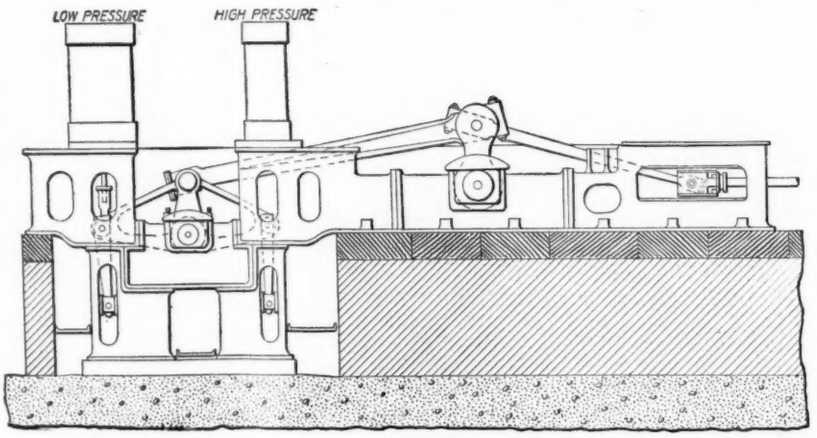


FIG. 8. SHOWING CRANK CONNECTIONS BETWEEN ENGINE AND COMPRESSOR

for that reason as constant a speed as is possible is maintained. In mining, the efficiency of the drills and other cutting tools has a great bearing on the production of the mine. If a compressor can maintain the required pressure, it stands to reason that the drills will do more work in a given period than they will at a reduced air pressure.

"Then there is the question of economy. A good deal of progress has been made in compressor design over the earlier types, and the clearance in the air cylinder

has considerable to do with it. I think I am safe in saying that the old types of compressors were not in it with the latest development. We have talked on the advantages of the intercooler and the aftercooler, water-jacketing, etc., but clearance has to be taken into account as well, and it is something that cannot be wholly done away with, because there must be some space between a piston and the cylinder head at the end of the stroke. Then there is the volume of the inlet and discharge passages between the valves and the cylinder. A good compressor will be so designed as to have this clearance space as small as possible in proportion to the volume swept through by the piston. This is because the clearance space at the end of the stroke is filled with air at the terminal pressure, which has got to expand back to the initial pressure before the inlet valve is opened.

"If a machine has an excess clearance space, it must run faster to produce a given capacity, which of course causes a greater friction; and although the air confined in the clearance space expands to the initial pressure, thus exerting pressure on the piston, it does not give back as much power as was used in compressing it. It is a good idea to use a small-diameter cylinder with a long stroke for the required air, rather than a large diameter and short stroke."

"Well, it seems that it requires as much intelligence to buy the proper kind of a compressor for a particular work as it does a steam engine. I had an idea that a compressor was a compressor and that one was as good as another."

"Well, here is something you can paste in your hat regarding the essential features of a compressor as far as economy is concerned. Always see that the percentage of clearance and the proportion of area of the clearance surface to the cylinder volume is as small as possible, and that the inlet and outlet areas are large, to reduce friction losses and heating as well as to make it possible for the cylinder to be filled with air even at high speeds. It is important also that the air should pass through short ports in what we might call a solid stream and over as little heating surface as possible.

"Jacketing the cylinders will take away considerable heat, and as a matter of convenience in cleaning as well as better service, it is well to have the water space and piping large; and after the machine is running, attention should be given to keeping the cooling water clean and free from sediment. If the compressor operates with small cooling spaces and dirty water, the circulation will probably become clogged with mud, which may become baked in a solid mass.

"As to the matter of stages, it is advisable to use a two-stage machine for anything above a moderate pressure of, say, 65 lb., and you will find a lot of two-stage units working at that and at even lower pressures where the capacity is considerable. For very high pressures three and even four stages are used, but don't forget that the air must be cooled between stages, otherwise much of the advantages of compounding will be lost.'

After quite a stay at this most interesting compressor installation, we proceeded to No. 4 Calumet plant.

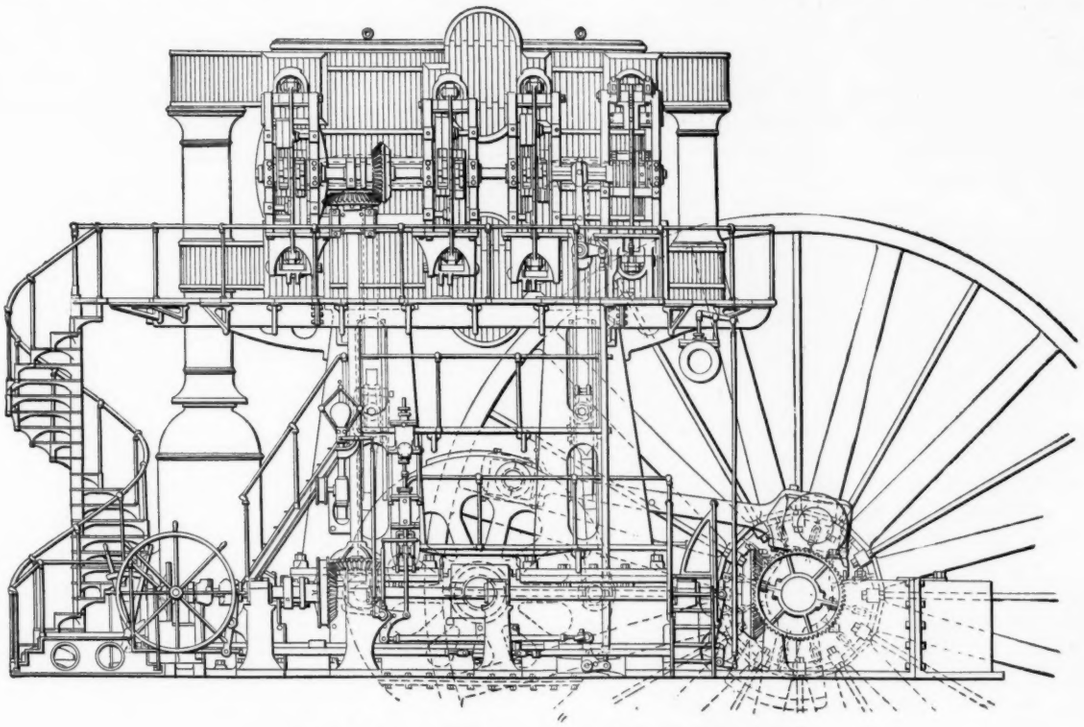


FIG. 9. SIDE ELEVATION OF SUPERIOR ENGINE

Within wide limits the rate of feeding air to a furnace has practically no effect on the composition of gases within the fuel bed, but affects directly the rate of combustion. In other words, if the amount of air forced through the fuel bed in a given time be doubled, the rate of combustion of the fuel is doubled, so that the weight of air forced through the fuel bed per pound of fuel burned or gasified is constant. Therefore, for complete combustion air must be added over the fuel bed as the gases rising from the fuel bed contain a high percentage of combustible and no free oxygen and this deficiency cannot be remedied by increasing the rate of air supply through the fuel bed.—*U. S. Bureau of Mines.*

Synchronous Motor Operation—II

By GORDON FOX

Direction of rotation, effects of voltage variation upon the starting torque, hunting effects, and the limitations of the synchronous motor are discussed. The first article appeared in the issue of Sept. 4, 1917.

THE speed of a synchronous motor is equal to the circuit frequency times the number of poles divided by 120, the same as for the synchronous speed of an induction motor. If the frequency of the circuit is constant, the speed of the motor is constant, regardless of the load.

The direction of rotation of a polyphase synchronous motor is that of the rotation of its revolving field. This is determined by the relations of the primary connections. Rotation may be reversed by reversing any two alternating-current terminals of a three-phase machine or by interchanging the two leads of one phase of a two-phase machine. A single-phase synchronous motor operates equally well in either direction and runs in the direction in which it is started by an auxiliary machine or mechanism.

The maximum torque of a synchronous motor varies as the square of the applied voltage. A drop in line voltage therefore affects the maximum capacity seriously. The maximum torque depends somewhat upon its field excitation. The stronger the field the more stable the operation and the less the probability of stalling. Over-excitation causes heavy wattless current, so that too strong excitation will limit the motor's capacity through heating rather than through pulling power. With normal excitation the pull-out torque is usually about twice full-load torque.

Applications of Synchronous Motors

Synchronous motors are used for various purposes: To operate as motors carrying mechanical load only; to operate as synchronous condensers for power-factor correction, with no mechanical load; to perform both services simultaneously. The degree of excitation required depends upon the service for which the machine is intended. Fig. 1 shows the so called V-curves of a synchronous motor. These curves illustrate how the armature current changes with different degrees of excitation. With a given load, a definite excitation gives minimum armature current. This point corresponds to 100 per cent. power factor. At other excitations there is more or less wattless current, the amount depending upon the departure from unity power-factor excitation. These curves show the relations for no-load operation, for operation with half rated mechanical load and with full rated mechanical output. The full lines apply to armature-current values; the dotted lines show corresponding values of power factor.

When a synchronous motor is operated purely to carry mechanical load, its field is best excited to such a point that the power factor is unity. The absence of wattless current permits minimum current input and highest efficiency, under these conditions. As the mechanical load changes, the power factor will vary slightly. A machine may have a slightly leading power factor with a given excitation under light load. As the load increases, the rotor poles fall back so that they are not so nearly opposite the stator poles, and their magnetizing influence is less effective. Unity power-factor conditions will then be approached. Still further increase of load may even cause a lagging current to flow. Well-designed motors do not vary their power factor rapidly with changes of load. Since operation is more stable with overexcited fields and since the power factor becomes lagging with increase of load, it is sometimes advisable to overexcite the fields slightly, particularly with fluctuating loads.

If a synchronous motor is to be operated idle, without load, for power-factor correction only, it may be built lighter in some respects, having a smaller shaft and bearings, for instance. Such a machine is not in reality a motor at all, being more correctly termed a synchronous condenser. The field excitation may be varied to such an extent that the armature current attains its full-rated value, being almost entirely wattless. In this case the machine exerts its maximum corrective influence and operates at almost zero power factor. If it is simply desired to raise the power factor of a system

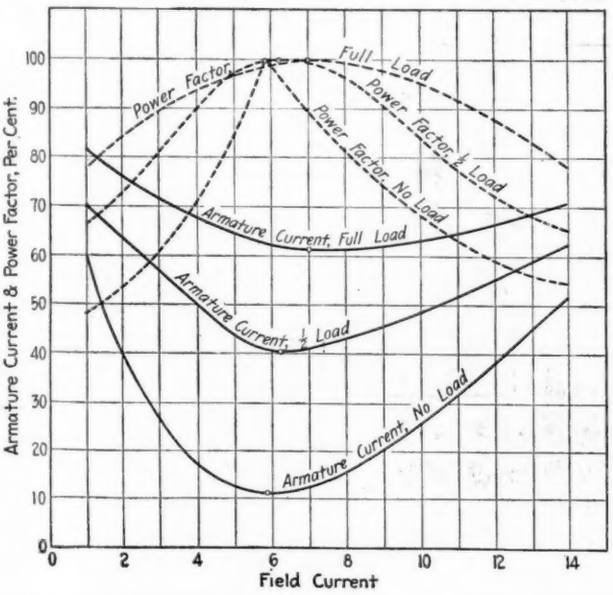


FIG. 1. SYNCHRONOUS-MOTOR CHARACTERISTIC CURVES

to a definite value, the excitation may be adjusted for a lesser amount of wattless current, just sufficient to accomplish the purpose. If the power factor of the system varies, this adjustment may be made automatically, if desired, by means of a voltage regulator.

Fig. 2 shows a 3000-kv.-a. three-phase 60-cycle 2300-volt synchronous condenser for voltage regulation which is excited by 125-volt direct-connected exciter *E*. The machine is controlled from the switchboard on the right of the figure. The small motor-generator set *M* on the base of the synchronous motor is used to furnish power to the automatic voltage regulator *R* of the broad-range type.

If a synchronous motor is to be used for combination service, to carry a mechanical load and also to correct the power factor, it must be larger than if it were to perform either service alone. The capacity of the motor is limited by the heating of the stator conductors. When the machine is carrying load at 100-per cent. power factor, no wattless current is involved, so that the current is all effective in producing mechanical output. Operating as a synchronous condenser at low power factor, the current is nearly all wattless and is most effective in its corrective influence. With combined service, both load and wattless components exist. A combination unit is most effective when the mechanical load is about 70 per cent. of the full horsepower rating for motor service alone. If the excitation is adjusted so that rated full-load current is taken, the wattless component will also be about 70 per cent. of its value for condenser service alone. The power factor of the motor under these conditions is about 70 per cent. It will be seen that combination service is efficient in that dual purposes are accomplished in a single unit almost as effectively as if the unit were used for but one service.

The synchronous motor adjusts itself to changes in load or circuit conditions by relocation of the angular position of the rotor fields with respect to that of the stator. It is an easy matter, in the case of such adjustment, for the rotor to overreach in its corrective action and to thus set up an oscillation ahead and behind its correct angular position. This action, called hunting, may be set up by line disturbances, irregular prime-mover rotation or cyclic load variations. The presence of a squirrel-cage winding in the polepieces (Fig. 2, Part I, Sept. 4 issue) greatly restricts the amplitude of such hunting and quickly damps out the oscillations. This is done through the action of local currents in the damping circuit, set up by the shifting magnetism incident to the hunting action. Hunting is less violent with heavily excited fields because the amount of angular variation for a given load change is less than with weak fields.

Polyphase motors connected to reciprocating machines, such as air compressors, have irregular loads impressed upon them. In such cases flywheels are necessary to store energy during one part of the revolution and deliver it during another part. The impulses of power received and delivered by the flywheel give it a certain period of oscillation, depending upon its dimensions. This period of oscillation should not correspond to the natural period of oscillation of the motor. This feature cannot be determined by the user, but, in purchasing, the coöperation of motor builder and machine builder must be arranged for.

The greatest advantage of the synchronous motor is its high power factor and its use for power-factor correction. Another advantage, which may sometimes be important, is its constant and maintained speed. The efficiency of a synchronous motor at full load is usually higher than that of a corresponding induction motor. At fractional loads the comparison usually favors the induction motor. This is because the excitation energy required for the synchronous motor is comparatively high, irrespective of the load, whereas the secondary losses of the induction motor increase with rise of load. The synchronous motor is well adapted for use on high-voltage lines as its stator is usually built with fewer and larger slots than are used for the induction motor; therefore the windings are easier to insulate. For large sizes and low speeds the synchronous motor may be cheaper than the equivalent induction motor.

The synchronous motor has a number of inherent disadvantages. Foremost is its lack of starting torque. This fault is being overcome to a considerable extent in the newer designs. Fairly skilled attention is required to operate the machine properly. Its speed cannot be varied; it is therefore suited to constant-speed drives alone. It requires an exciter or excitation from some external source. A switchboard should be provided for proper control; that is, equipped with line and field switches, a starting compensator if the machine is self-starting, rheostats for motor and exciter fields, an ammeter and a power-factor meter. If the motor is not self-starting, equipment for the auxiliary starting motor is required, together with a voltmeter and synchronizing lamps or a synchronoscope. The cost of this amount of control equipment is prohibitive to the use of synchronous motors in small units. Lack of entire stability, with a tendency to hunt or fall out of step from line disturbances, has been in the past unfavorable to the extensive use of motors of this type. Recent developments in design, however, have made the synchronous motor, properly applied, quite as reliable as the induction motor in the great majority of cases. If supplied with damping windings and operated with a strong field, its hunting tendencies need now be little feared.

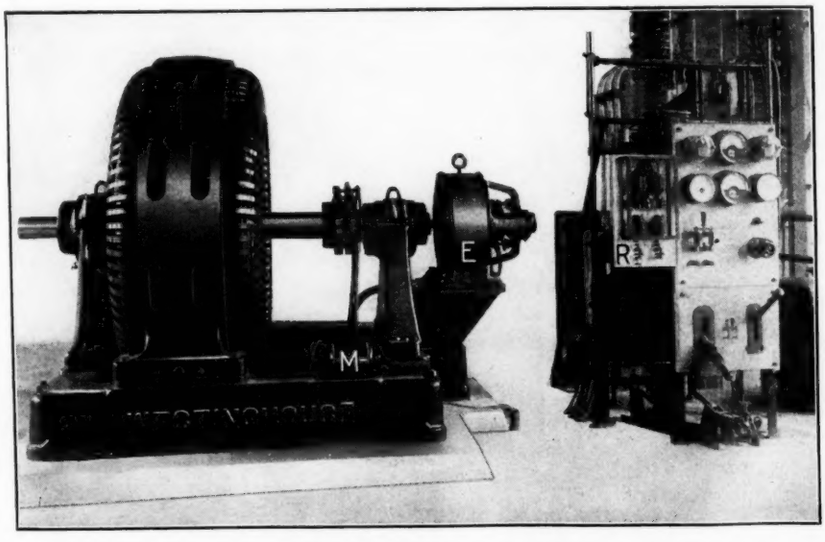


FIG. 2. SYNCHRONOUS CONDENSER FOR VOLTAGE REGULATION

In spite of its disadvantages the synchronous motor finds considerable use and is becoming increasingly popular. Its ability to raise the power factor of the system to which it is connected, is nearly always the one advantage that dictates its use. Most often it is applied

as the driving unit of a motor-generator set. But it may be used for any load requiring constant speed and infrequent starting, which may be reduced at starting and which does not fluctuate rapidly. Fans, air compressors and pumps are frequently driven by motors of this type. The machine is probably applied more frequently as a synchronous condenser only, than in connection with a mechanical load.

The synchronous motor has an action, not previously mentioned, which renders it valuable in certain instances. This is its ability to balance the voltages in the different phases of unbalanced systems. This is brought about through the more marked influence of leading current in the low phase. If a slightly overexcited motor is operated upon an unbalanced polyphase system, all the phases will draw leading current, but the action is most pronounced in the phase having less than normal voltage. This action tends to balance the circuit, both in voltage and current, because the excess leading current neutralizes a greater amount of lagging current in the low phase.

Some Things About Pipes

By W. D. Forbes

When ordering brass pipe "iron-pipe size" must be specified or tubing of lighter weight may be delivered and, as a rule, it is then only necessary to give its nominal inside size when ordering standard brass pipe, but there are two thicknesses of iron-pipe size to be obtained, standard and extra-heavy, each in 12-ft. lengths. In neither case is the pipe threaded nor are couplings furnished unless so specified in the order. The sizes carried in stock run from $\frac{1}{8}$-in. to and including 6-in., in regular temper and annealed. It is also obtainable nickel-plate, tinned or polished. Copper pipe can be purchased in all the foregoing sizes, weights and finishes.

Steel and iron pipe can be obtained in weight of thickness of walls known as standard, extra-strong and double-extra-strong or hydraulic pipe in lengths varying from 18 to 20 feet. All sizes from $\frac{1}{8}$-in. to $1\frac{1}{2}$-in. inclusive are bundled for shipment and sizes above $1\frac{1}{2}$-in. are shipped loose. Pipe 4-in. and larger is provided with protectors to keep the threads from being injured in transit. Standard pipe is always threaded and provided with a coupling for each length. Extra-strong and double-extra-strong pipe is never threaded nor are couplings provided except when ordered and at an extra charge. All sizes and weights can be obtained black or galvanized. When galvanized, the threads are cut after the galvanizing is done, so it is necessary when shipping and after installing to paint or in some way protect that part of the thread which shows outside the coupling or fitting, if the job is to be a lasting one. The threads on all piping are made tapered $\frac{3}{4}$ in. to the foot, that is, $\frac{3}{8}$-in. taper each side of a central line, and the threads are cut at right angles to the taper.

It must be remembered that extra-strong and double-extra-strong pipe does not vary in outside diameter, but the walls are increased in thickness by reducing the size of the hole; it is therefore clear that the carrying capacity of such pipe is reduced.

The regular sizes are $\frac{1}{8}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, $3\frac{1}{2}$ and 4 in. Above 4 in. diameters increase by even inches.

Draft in Boiler Practice

By H. F. Lawrence
Test Engineer American Engineering Co.

With forced-draft furnaces the air for combustion is supplied at a pressure beneath the fuel bed, the extra pressure serving simply to force the air through the fuel bed; but the stack should provide draft of sufficient intensity to urge the gases of combustion along the heating surfaces, through the breeching and flues and to discharge them from the stack. With natural-draft furnaces, the stack, in addition to doing all that it does for forced draft, must also supply draft of sufficient intensity to draw the air through the fuel bed. In the design of stacks the height is determined by the intensity of draft required and the area is determined by the volume of the gas or the rate at which it is necessary to burn the fuel.

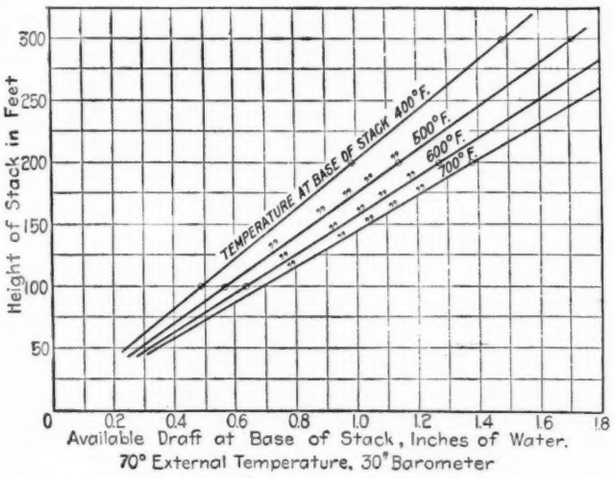


FIG. 1. NORMAL DRAFT IN STACKS OF GIVEN HEIGHT

Fig. 1 gives the available draft at the base of the stack for different heights and temperatures. With "Taylor" stokers the following formulas have given good results for determining the stack area which is required:

$$A = \frac{F}{21.8\sqrt{H}}$$

in which

A = Area in square feet;
F = Fuel burned per hour;
H = Height above grates in feet.

Example: What diameter and height of stack is required to develop 200 per cent. of rated capacity on six 500-hp. boilers with Taylor stokers with coal of 14,000 B.t.u.?

To develop 200 per cent. of rating will require approximately 20,000 lb. of coal per hour.

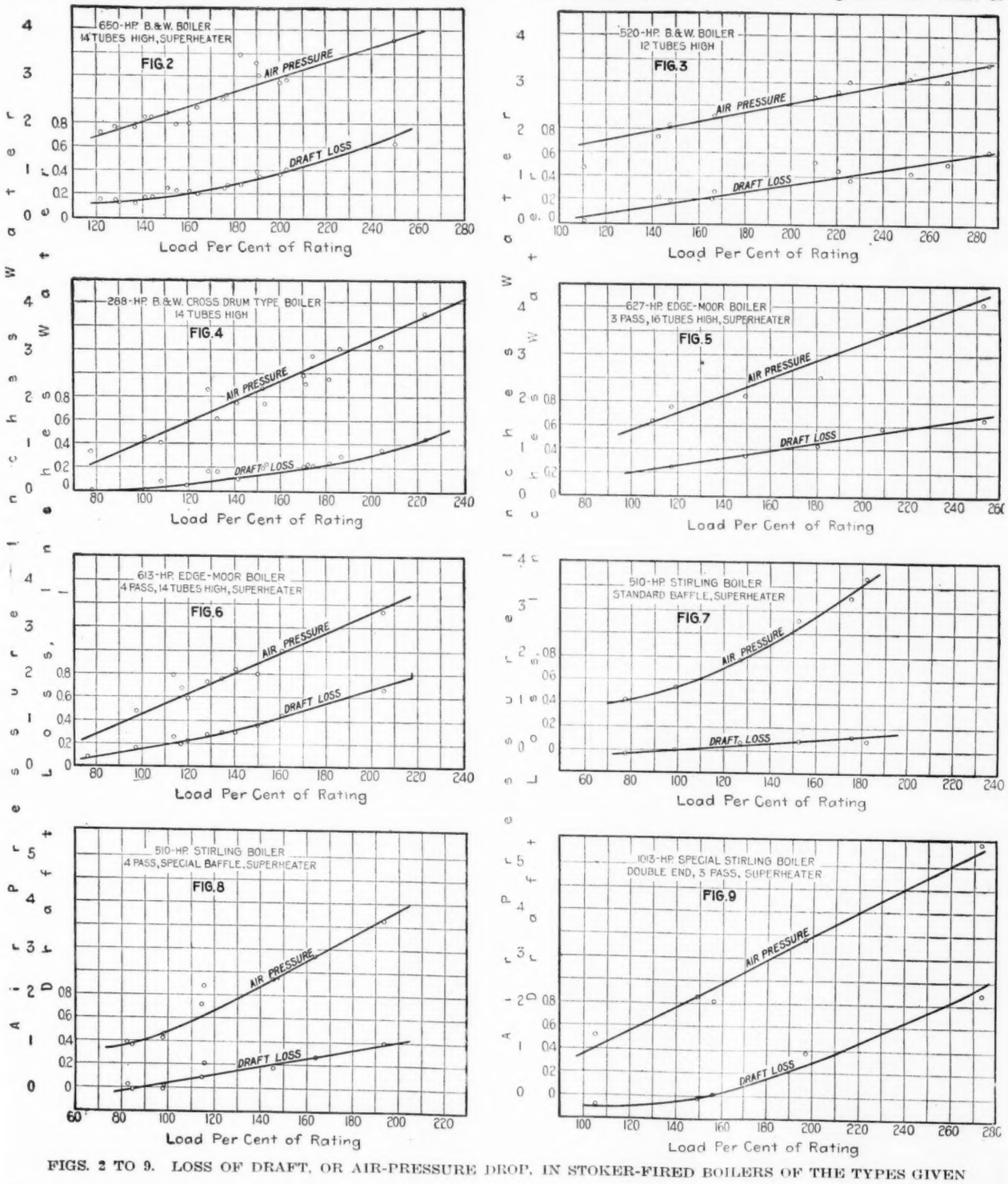
Temp. at base of stack	500° F.
Draft required over fire	0.1 in.
Draft drop through boilers	0.6 in.
Draft loss in breeching	0.2 in.
Total draft required at base of stack	0.9 in.

Referring to Fig. 1 we note that a stack 158 ft. above grates will produce a draft of 0.9 in. when the temperature at the base is 500 deg. F.

$$Area = \frac{20{,}000}{21.8\sqrt{158}} = 74\ sq.ft. \qquad Diameter = 9.75\ ft.$$

Figures 2 to 9 inclusive show the air pressure and draft drop, or loss, in various types of boilers equipped with Taylor stokers. These results are obtained from a series of tests in each case, the test points which determine the curve being indicated. After all, the most reliable information on stack draft is that derived from actual practice, when such data are obtained from careful and competent observation, because there are so many disturbing elements. A good general average of a number of tests is applicable to an average case and an abnormal condition operating against or in favor of a given installation must be taken into consideration.

In the Stirling boilers at the low ratings the draft-drop curve crosses the line of zero draft loss. At this point the draft caused by the stack effect of the high combustion chamber equals the draft required at the boiler dampers, while at the lower points the draft is greater than that required at the damper. In the case of the double-end Stirling boiler this effect was so great that the boiler could have been operated up to about 140 per cent. of rating without any stack at all, there being a pressure throughout the setting, except in the combustion chamber. This condition, however, is not frequently met with.



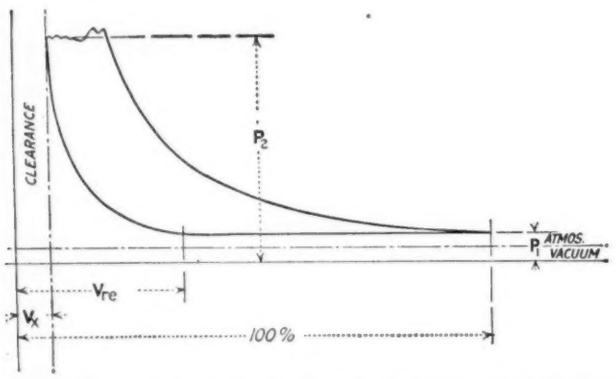
FIGS. 2 TO 9. LOSS OF DRAFT, OR AIR-PRESSURE DROP, IN STOKER-FIRED BOILERS OF THE TYPES GIVEN

Mean Effective Pressure of Ammonia Compressors

By Carl J. Jefferson

Until recently, it has been the aim of all ammonia-compressor designers to reduce clearance to a minimum with the idea of producing maximum volumetric efficiency. Now designers are abandoning this line of attack and are endeavoring to develop a machine which produces a maximum combined efficiency, including the prime mover.

The introduction and rapid strides of the electric motor, the oil engine, gas engine and uniflow steam engine, as prime movers for ammonia compressors, have resulted in the development of the high-speed machine. To meet the mechanical difficulties of this machine, the question of clearance has been brought into play. The valve design has caused greater necessary clearance. The cushioning of the inertia effects produced by rapidly moving reciprocating parts has been effected by increased clearance. In order to secure capacity, the piston displacement is increased, which is easily accomplished by slightly enlarging the bore of the compressor.



COMPRESSOR DIAGRAM WITH 8 PER CENT. CLEARANCE

The majority of the contracts made for current between refrigerating companies and the electrical companies base the charge on maximum demand, covering a period of 15 minutes to half an hour. With the compressor direct-connected to a synchronous motor, it is impossible to slow down the machine in cases of excessive head pressure, and as a result the load goes up with the no-clearance machine and the current charge for the week is made on this peak load. To forestall such a condition with the new-type high-speed compressor, an adjustable clearance can be provided which will keep the load curve flat.

Use of the Tables

These conditions, produced by varying the clearance, call for a new set of M. E. P. tables in order that the consulting engineer and operating engineer can intelligently figure out the theoretical load values.

The accompanying tables have been compiled with this idea in view. They represent the mean effective pressure which will be produced by the adiabatic compression of the gas and the adiabatic reëxpansion of the gas in the clearance space, the gas being saturated.

The formulas used in these computations are as follows:

$$M.E.P.\ no\ clearance = P_1 \frac{k}{k-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} - 1\right]$$

$$M.E.P.\ with\ x\ \%\ clearance =$$

$$P_1 \frac{k}{k-1}\left[\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} - 1\right] \times \left[1 - V_x\left(\frac{P_2}{P_1}\right)^{0.77}\right]$$

$$k = \frac{CP}{CV} = \frac{spec.\ heat\ NH_3\ at\ constant\ press.}{spec.\ heat\ NH_3\ at\ constant\ vol.}$$

$$= 1.3, \text{ and } \frac{1}{k} = 0.77$$

$$V_{re} = V_x\left(\frac{P_2}{P_1}\right)^{0.77}$$

Simplifying,

$$M.E.P. = 4.33 \times P_1\left[\left(\frac{P_2}{P_1}\right)^{0.23} - 1\right] \times [100\% - V_{re}]$$

V_x and V_{re} are used as percentages.

The accompanying tables are the values obtained by the formula and give the mean effective pressures from 0 to 10 per cent. clearance with suction pressures from 5 to 30 lb. gage and head pressures from 100 to 240 lb. gage, using saturated ammonia gas as the gas of compression.

NO CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage														
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	42.97	45.48	47.83	50.08	52.25	54.25	56.16	57.98	59.72	61.45	63.10	64.67	66.14	67.62	68.75
10	45.68	48.61	51.43	54.03	56.53	58.92	61.19	63.47	65.53	67.49	69.44	71.39	73.13	74.87	76.60
15	47.13	50.65	53.77	56.77	59.63	62.50	65.10	67.70	70.05	72.39	74.60	76.82	78.77	80.85	82.81
20	47.70	51.65	55.29	58.79	61.98	65.17	68.05	70.94	73.52	76.25	78.68	81.11	83.55	85.67	87.95
25	47.74	52.08	56.07	59.89	63.53	67.00	70.13	73.25	76.38	79.16	81.93	84.71	87.32	89.92	92.18
30	47.06	51.75	56.05	60.34	64.25	68.15	71.67	74.99	78.31	81.63	84.56	87.49	90.22	92.96	95.89

ONE PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage														
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	41.34	43.62	45.73	47.78	49.74	51.49	53.18	54.77	56.27	57.76	59.17	60.50	61.73	62.97	63.87
10	44.20	46.93	49.55	51.94	54.22	56.40	58.45	60.51	62.35	64.05	65.80	67.51	69.02	70.53	72.02
15	45.81	49.13	52.06	54.86	57.52	60.18	62.57	64.95	67.09	69.21	71.20	73.19	75.03	76.78	78.51
20	46.51	50.28	53.73	57.04	60.03	63.02	65.70	68.39	70.77	73.28	75.58	77.71	79.92	81.84	83.89
25	46.66	50.82	54.64	58.26	61.73	65.00	67.94	70.87	73.78	76.37	78.94	81.49	83.91	86.29	88.34
30	46.10	50.61	54.74	58.86	62.59	66.30	69.63	72.76	76.00	79.00	81.74	84.47	87.00	89.53	92.25

TWO PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage														
	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	39.71	41.75	43.62	45.47	47.23	48.74	50.19	51.55	52.82	54.08	55.24	56.33	57.32	58.31	58.99
10	42.72	45.26	47.67	49.85	51.92	53.88	55.71	57.54	59.15	60.67	62.16	63.64	64.92	66.19	67.44
15	44.48	47.61	50.34	52.95	55.40	57.86	60.04	62.20	64.13	66.03	67.80	69.57	71.08	72.70	74.21
20	45.32	48.90	52.16	55.28	58.08	60.86	63.35	65.83	68.01	70.30	72.31	74.31	76.30	78.01	79.82
25	45.58	49.57	53.21	56.66	59.92	62.98	65.75	68.49	71.19	73.59	75.95	78.27	80.49	82.65	84.49
30	45.12	49.47	53.44	57.37	60.92	64.44	67.58	70.54	73.47	76.37	78.91	81.45	83.78	86.11	88.59

THREE PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	38.07	39.89	41.52	43.17	44.73	45.98	47.21	48.33	49.37	50.39	51.31	52.16	52.91	53.66	54.11
10	41.24	43.58	45.78	47.76	49.62	51.36	52.98	54.58	55.97	57.23	58.52	59.75	60.81	61.84	62.86
15	43.15	46.09	48.63	51.04	53.29	55.53	57.51	59.45	61.16	62.86	64.40	65.95	67.25	68.63	69.90
20	44.13	47.52	50.60	53.52	56.04	58.71	61.00	63.26	65.26	67.32	69.13	70.91	72.68	74.17	75.77
25	44.51	48.32	51.78	55.04	58.12	61.01	63.57	66.10	68.61	70.79	72.95	75.10	77.07	79.02	80.66
30	44.15	48.34	52.13	55.89	59.26	62.59	65.55	68.30	71.05	73.75	76.10	78.43	80.56	82.68	84.95

FOUR PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	36.44	38.02	39.41	40.87	42.22	43.23	44.23	45.12	46.13	46.70	47.39	47.99	48.50	49.00	29.23
10	39.76	41.90	43.89	45.67	47.32	48.84	50.24	51.61	52.78	53.84	54.88	55.88	56.71	57.51	58.27
15	41.83	44.57	46.92	49.13	51.18	53.21	54.98	56.71	58.21	59.68	61.00	62.32	63.40	64.55	65.60
20	42.94	46.14	49.03	51.77	54.18	56.56	58.65	60.71	62.50	64.35	65.95	67.52	69.06	70.34	71.71
25	43.43	47.06	50.34	53.42	56.31	59.01	61.38	63.71	66.02	68.01	69.96	71.89	73.65	75.39	76.82
30	43.18	47.20	50.83	54.40	57.59	60.74	63.51	66.08	68.63	71.12	73.28	75.41	77.34	79.26	81.30

FIVE PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	34.81	36.16	37.43	38.56	39.71	40.47	41.24	41.90	42.47	43.02	43.46	43.82	44.09	44.35	44.34
10	38.28	40.26	42.01	43.57	45.01	46.32	47.50	48.65	49.59	50.44	51.23	52.01	52.60	53.17	53.70
15	40.41	43.04	45.21	47.23	49.06	50.89	52.44	53.96	55.24	56.50	57.60	58.70	59.56	60.48	61.30
20	41.75	44.77	47.46	50.01	52.23	54.40	56.30	58.15	59.74	61.37	62.76	64.11	65.44	66.51	67.65
25	42.35	45.81	48.91	51.80	54.51	57.02	59.20	61.33	63.43	65.22	66.96	68.68	70.24	71.76	72.98
30	42.21	46.06	49.52	52.91	55.93	58.87	61.47	63.85	66.20	68.50	70.46	72.38	74.12	75.83	77.65

SIX PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	33.17	34.29	35.20	36.26	37.20	37.71	38.26	38.69	39.03	39.33	39.53	39.66	39.68	39.69	39.46
10	36.80	38.54	40.13	41.48	42.71	43.80	44.77	45.69	46.41	47.03	47.59	48.13	48.49	48.82	49.11
15	39.18	41.52	43.50	45.32	46.95	48.56	49.92	51.21	52.29	53.32	54.20	55.07	55.72	56.40	56.99
20	40.55	43.40	45.91	48.25	50.28	52.25	53.95	55.59	56.99	58.40	59.58	60.71	61.81	62.68	63.59
25	41.27	44.56	47.48	50.19	52.70	55.02	57.01	58.95	60.85	62.43	63.97	65.48	66.83	68.12	69.14
30	41.24	44.93	48.21	51.43	54.27	57.02	59.43	61.63	63.78	65.88	67.60	69.36	70.89	72.41	74.01

SEVEN PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	31.54	32.43	33.10	33.96	34.69	34.96	35.27	35.47	35.58	35.64	35.60	35.48	35.27	35.03	34.58
10	35.32	36.86	38.08	39.39	40.40	41.29	42.03	42.72	43.22	43.61	43.96	44.25	44.38	44.48	44.54
15	37.85	40.00	41.78	43.41	44.84	46.24	47.39	48.46	49.32	50.14	50.80	51.45	51.88	52.33	52.69
20	39.37	42.02	44.34	46.50	48.33	50.10	51.60	53.03	54.24	55.43	56.40	57.31	58.19	58.84	59.53
25	40.19	43.30	46.04	48.58	50.90	53.02	54.81	56.56	58.26	59.65	60.98	62.28	63.41	64.49	65.30
30	40.27	43.79	46.91	49.94	52.61	55.17	57.39	59.41	61.36	63.25	64.82	66.34	67.67	68.98	70.35

EIGHT PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	29.91	30.56	31.18	31.65	32.19	32.20	32.29	32.26	32.13	31.95	31.67	31.31	30.86	30.38	29.70
10	33.85	35.18	36.36	37.30	38.10	38.76	39.29	39.76	40.04	40.20	40.32	40.38	40.28	40.15	39.96
15	36.53	38.48	40.70	41.50	42.73	43.92	44.85	45.71	46.37	46.97	47.40	47.83	48.03	48.25	48.39
20	38.17	40.64	42.83	44.75	46.36	47.95	49.25	50.47	51.48	52.44	53.22	53.91	54.57	55.01	55.47
25	39.12	42.05	44.61	46.96	49.10	51.03	52.64	54.18	55.67	56.85	58.07	59.08	59.99	60.86	61.46
30	39.30	42.65	45.60	48.46	50.94	53.31	55.35	57.18	58.94	60.62	62.00	63.33	64.45	65.56	66.71

NINE PER CENT. CLEARANCE M.E.P.

Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	28.27	28.70	29.08	29.35	29.68	29.44	29.30	29.04	28.68	28.27	27.75	27.15	26.46	25.72	24.82
10	32.37	33.50	34.47	35.21	35.80	36.25	36.55	36.79	36.35	36.79	36.67	36.50	36.17	35.80	35.37
15	35.20	36.96	38.36	39.60	40.61	41.60	42.33	42.96	43.41	43.79	44.00	44.20	44.20	44.18	44.09
20	36.99	39.26	41.21	42.99	44.43	45.79	46.89	47.92	48.73	49.47	50.03	50.52	50.95	51.17	51.42
25	38.04	40.80	43.18	45.34	47.29	49.03	50.45	51.80	53.08	54.07	54.99	55.87	56.57	57.23	57.62
30	38.33	41.52	44.30	46.97	49.28	51.46	53.32	54.95	56.52	58.00	59.18	60.30	61.23	62.13	63.06

TEN PER CENT. CLEARANCE M.E.P.

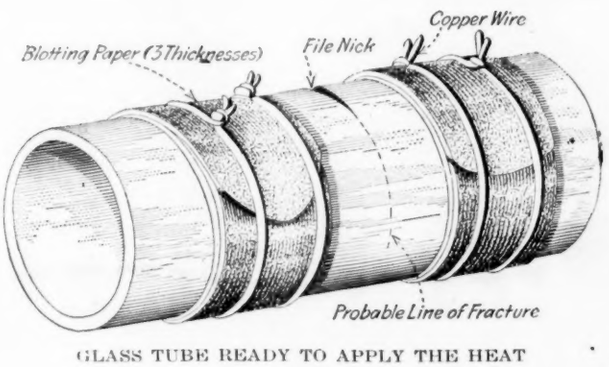
Suction Pressure Gage	Head Pressure Gage 100	110	120	130	140	150	160	170	180	190	200	210	220	230	240
5	26.63	26.83	27.02	27.06	26.97	26.70	26.32	25.83	25.23	24.57	23.81	22.98	22.04	21.06	19.94
10	30.89	31.82	32.59	33.12	33.49	33.73	33.81	33.83	33.66	33.38	33.03	32.63	32.07	31.46	30.80
15	33.88	35.44	36.64	37.68	38.50	39.28	39.80	40.15	40.45	40.61	40.60	40.58	40.35	40.10	39.78
20	35.79	37.89	39.65	41.24	42.48	43.64	44.55	45.36	45.97	46.50	46.85	47.12	47.32	47.34	47.35
25	36.96	39.54	41.75	43.73	45.49	47.03	48.26	49.41	50.49	51.28	52.00	52.66	53.16	53.59	53.78
30	37.36	40.38	42.99	45.49	47.62	49.61	51.27	52.73	54.10	55.37	56.36	57.28	58.01	58.70	59.41

Cutting Large Glass Tubing

By M. A. Saller

It is sometimes necessary to cut large-diameter glass tubing for making water-level indicators, etc., and trouble is often experienced in securing a good clean cleavage at the point desired. For this work a method I have seen used by a glass worker may be successfully employed.

The glass tube is nicked with a file or a cutter at the point where the fracture is desired. Then three or four thicknesses of blotting paper are wrapped around the tube about ⅛ in. from each side of the mark, the



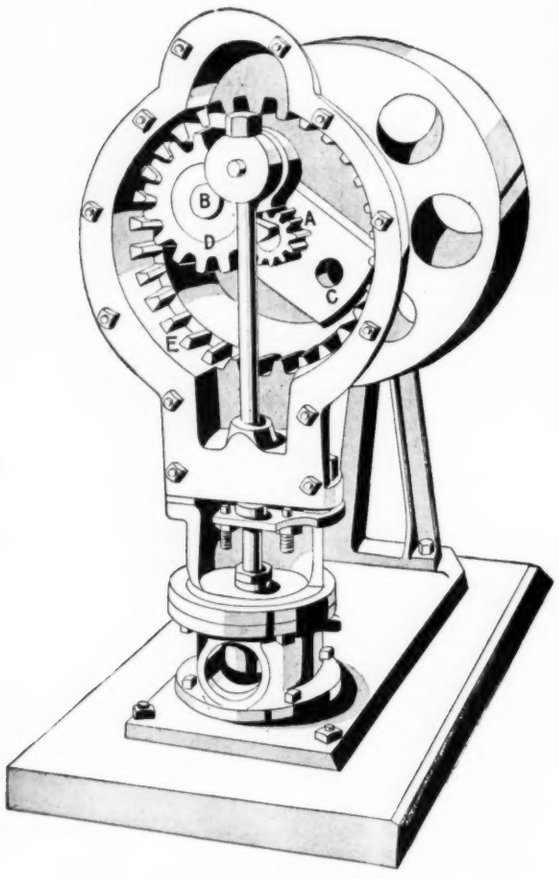
GLASS TUBE READY TO APPLY THE HEAT

blotting paper being held in place by copper wires, as shown in the illustration. The blotters are then soaked with water, and the narrow section of tube between the two wet blotters is exposed to the heat of a bunsen burner. The strains set up between the cool part beneath the blotters and the hot part exposed to the flame will cause a fracture starting at the file nick and extending in almost a straight line around the tube. This method can be used to good advantage on large tubing, say 1 to 3 in. diameter.

Carlson Pump Jack

There have been manufactured a number of pump jacks for operating drilled well pumps, and one that is of interest and in which the crank rod has a vertical movement up and down at all times is being manufactured by A. Carlson, 91 South Riverside St., Klamath Falls, Ore. It is illustrated herewith with belt drive.

This pump jack consists of a shaft that runs in suitable bearings. One end of the shaft carries a belt pulley; to the other end, which extends into the casing head, is keyed a pinion *A* that meshes with a spur gear (not



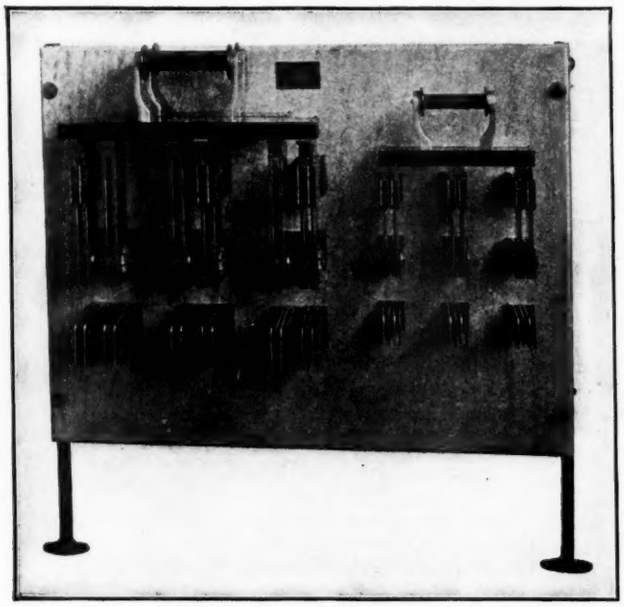
BELT-DRIVEN PUMP JACK

shown) loosely fitted to a stud *B;* the latter in turn is secured to an arm *C*. This arm is loosely mounted on the driving shaft intermediate with the pinion *A* and the back wall of the casing. On the stud *B* there is also mounted a large spur gear *D*, which is made fast to a gear back of it driven by the pinion *A*. The gear *D* meshes with internal gear teeth *E*, which are made annularly about the inner wall of the casing.

This arrangement gives the two gears on the stud *B* a planetary movement about the driving pinion *A*. The gear *D* is provided with a detachable crankpin to which is connected the crank rod, which operates in a vertical path and, being connected to the pump rod in the well, gives the same an up-and-down motion.

Split-Lever Starting Switch

In starting large synchronous converters from the alternating-current side, the three-pole starting switches are very heavy and difficult for the operator to manipulate. Until recently the only alternative was to put in a large solenoid-operated circuit-breaker, which added considerable expense to the installation. To extend the range of sizes of three-pole hand-operated



SYNCHRONOUS-CONVERTER STARTING SWITCH

starting switches, the General Electric Co. has developed the arrangement shown. The switch on the left is, in fact, two switches, each with its separate crossbar and handle, one in front of the other. In the up position, which is the starting side, only the blades attached to the long crossbar are in use, as shown. In this position the switch connects the converter's collector rings to low-voltage taps in the transformers. After remaining in this position long enough for the machine to come up to the proper speed, the part of the switch connected to the long crossbar is thrown to the down position. This portion of the switch is capable of carrying the current for a short period until the other part can be thrown down. Switches of this type have been built in sizes up to 5000 amperes.

The National Committee on Gas and Electric Service, of which John W. Lieb, of the New York Edison Co., is chairman, has been able, through its close touch with the gas and electric utility companies, to be of special service to the Quartermaster General's Department in connection with the troop cantonments.

Smoke Reduction in Boiler Furnaces

BY JOSEPH GODER
Member of Firm of Boiler Efficiency Engineers, Chicago.

Smoke production depends upon the nature rather than upon the volume of the volatile content of the coal. To prevent smoke, the thorough and early mixing of the air and volatiles is of prime importance. Efficient operation requires that as much heating surface as possible be exposed to the luminous flame and that the use of refractory brickwork be held to a minimum.

IT IS the intention of the writer to discuss the smoke problem, its causes and the principles involved in its efficient reduction, so that, although no specific exists to be applied blindly to every plant, the operating engineer may learn the natural laws governing the operation of boiler furnaces and may intelligently set about remedying his own faulty conditions or judge the merits of proposed installations. The widely different

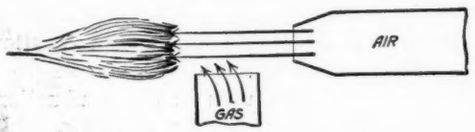


FIG. 1. BLOW-TORCH METHOD

operating conditions in boiler plants and the great difference in coals available do not permit the tabulation of any hard and fast set of rules for smoke abatement. Satisfactory results can be obtained only if the principles governing complete combustion are followed in the construction of the individual plant. The extent to which these principles have been followed in the design of the plant determines the efficiency or inefficiency of its operation.

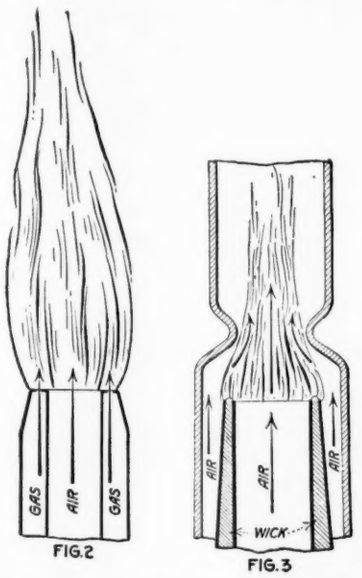
Before means can be found to reduce smoke, it is obvious that the causes of its production must be understood. The erroneous opinion prevails that black smoke contains a large amount of combustible matter and that it is a sign of greatly reduced economy. The most dense black smoke does not commonly contain more than ½ of 1 per cent. of the combustible fired. The extreme fineness and the distribution of the carbon particles bestow upon them a high coloring power. The losses are negligible in comparison with those due to incomplete combustion or excessive air, which generally accompany combustion without visible smoke. The carbon particles producing visible smoke are not derived from a lifting of fixed or solid carbon from the grates, but they are formed from gases during the combustion process.

Carbon in solid form as it is found in anthracite, coke, etc., combines under certain conditions with oxygen of the air to form carbon dioxide ($C + 2O = CO_2$). If an atom of CO_2 passing through the furnace meets an atom of free carbon (C) without at the same time encountering oxygen, it dissociates and gives up one of its oxygen components to the free carbon. This process is expressed in the chemical formula, $CO_2 + C = 2CO$. As soon, however, as the CO particles come in contact with other oxygen atoms under favorable temperature conditions, they combine to CO_2, the product of complete combustion.

As the ignition temperature of CO (the temperature at which the oxidation or combustion takes place) is comparatively low and generally prevailing in furnaces, it is necessary only to provide for sufficient oxygen and its proper distribution to obtain complete combustion. Inasmuch as both carbon monoxide (CO), the product of partial combustion, and carbon dioxide (CO_2), the product of complete combustion, are colorless gases, there is no visible sign to indicate whether the combustion process is complete or only partly so.

Most of the coals used as fuel in boiler furnaces contain substances that distill at low temperatures and are released when the coal is heated. These substances are commonly known as "volatile matter." The amount and nature of these distillates vary widely, and upon their composition depends the amount and nature of the smoke produced.

The volatile matter (this term does not include the moisture) is primarily composed of different combinations of hydrogen and carbon known under the general term of "hydrocarbons." These hydrocarbons differ primarily in the temperatures at which they boil (distill) and in their ignition temperatures. Furthermore,



FIGS. 2 AND 3. INFLUENCE OF AIR ON FLAME
Fig. 2—Incomplete mixing of gas and air. Fig. 3—Circular burner of kerosene lamp

the lighter volatiles remain in a gaseous state when they are cooled. The heavier ones, such as tar vapors, have a tendency to dissociate at certain temperatures, liberating the carbon particles.

If sufficiently high temperatures prevail in the combustion chamber, and these carbon particles come into contact with free oxygen, they burn completely. The incandescence of the highly heated carbon particles, be-

fore their complete combustion, produces the luminosity of the flame. If, however, oxygen is lacking in the combustion chamber, or if the oxygen does not come into contact with the carbon particles before the temperature drops below the ignition point, incomplete combustion takes place and the unburned carbon particles pass off as smoke.

Since the various hydrocarbons differ in their readiness to dissociate, it is evident that the smoke production of coal depends upon the nature rather than upon the volume of the volatile content. Some coals, despite their relatively high percentage of volatile matter, do not tend to produce smoke as readily as others with less volatile content, such as lignites.

Illuminating gas, which is high in hydrocarbon, can be burned without smoke and with a nonluminous flame in the bunsen burner. The gas is thoroughly mixed with air before its ignition. A close contact of

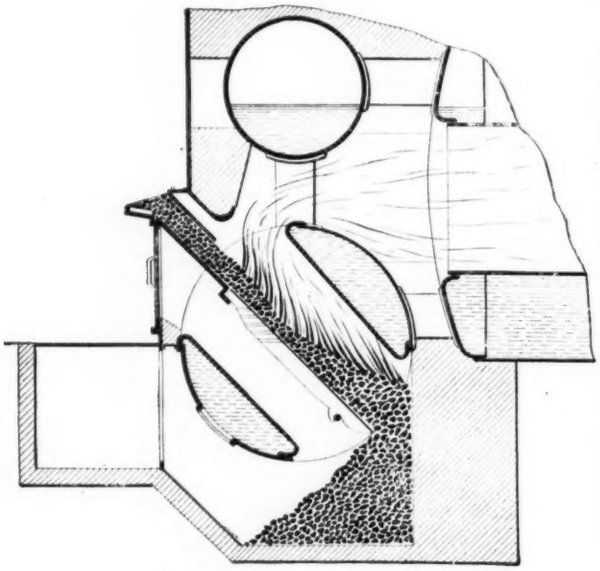


FIG. 4. TENBRINK FURNACE

oxygen and the gas particles is maintained, resulting in complete combustion of the hydrocarbons before they can release any of their carbon. In the furnace, however, these processes cannot be accomplished, as the temperatures at the burning point (the fuel bed corresponding to the outlet of the bunsen burner) are already sufficiently high to effect dissociation of the hydrocarbons before a proper mixture with air can be completed.

The open-slot gas burner illustrates the process more closely and indicates the requirements to bring about complete combustion of heavy hydrocarbons when dissociation of the hydrogen and carbon takes place. The luminosity of the flame from the slot burner results from the incandescent carbon particles liberated by the combustion of the hydrogen taking place in the darker, nonluminous zone of the flame. The thin and widely spread gas stream assures a close contact of the gases with the air. Therefore incandescent carbon particles quickly find the necessary oxygen and burn quickly and completely in a short, bright, smokeless flame.

However, if the burner tip is removed and the gas stream from the pipe is lighted, a long and smoky flame will result. This is caused by the incomplete and retarded contact of the incandescent carbon particles with the air. By directing a current of air into the gas flame at an angle of 90 deg., as in Fig. 1, a good mixture of air and gas is obtained, resulting in a short and smokeless flame. In Fig. 2 the mixture of gas and air is not as thorough. The lack of proper mingling produces slower combustion, resulting in a longer flame, and the necessity of an excessive amount of air reduces the temperature of the flame materially, further retarding the process of combustion.

A good illustration of the foregoing is the circular burner of the old-fashioned kerosene lamp. A long smoky flame is produced when the glass chimney is left off the burner. As soon as the chimney is in place a short and clear flame is developed. The chimney produces a draft, thus creating a higher air velocity, and by means of its circular contraction effects a good mixture of air and combustible gas, as shown in Fig. 3. The flame port over the bridge-wall in a boiler furnace may be designed to achieve a similar effect.

Summarizing, the hydrocarbon gases can be completely and smokelessly burned if sufficient air is thoroughly mixed with the gases before they cool below a certain temperature. Applying these principles to the combustion of volatiles in the boiler furnace, the following requirements must be met to effect complete and smokeless combustion: (1) Introduction of the proper amount of the air to complete combustion; (2) effective and early admixture of air and volatiles; (3) sufficiently high temperatures in the combustion zone.

The complete fulfillment of these three cardinal conditions of smokeless combustion is rather difficult to obtain in the boiler furnace, especially the second requirement. Undue consideration is generally given to the maintenance of high temperatures in the combustion space. In the great majority of cases insufficient air and particularly incomplete mixture are the causes of the smoke production. This is especially true where bituminous coals are burned.

If care is taken to effect an early and complete mixture of sufficient air with the combustible gases, satisfactory combustion can be obtained in furnaces that are completely surrounded by heating surfaces. The best proof of this statement is the Tenbrink furnace shown in Fig. 4. In fact, it has been shown that in well-designed and operated internally fired boilers, wood shavings can be burned without smoke nuisance, provided that care is taken to supply the proper amount of air and to effect its early admixture with the volatiles. The presence of heat-absorbing surfaces proves rather beneficial for smoke reduction as it retards the distillation of volatiles, thus equalizing to a certain extent the varying air demand in hand-fired boilers. Good mixture of the air and combustible gases accelerates the combustion, thus creating a short, high-temperature flame, as in the case of the slot burner and the flame produced by means of the blowpipe.

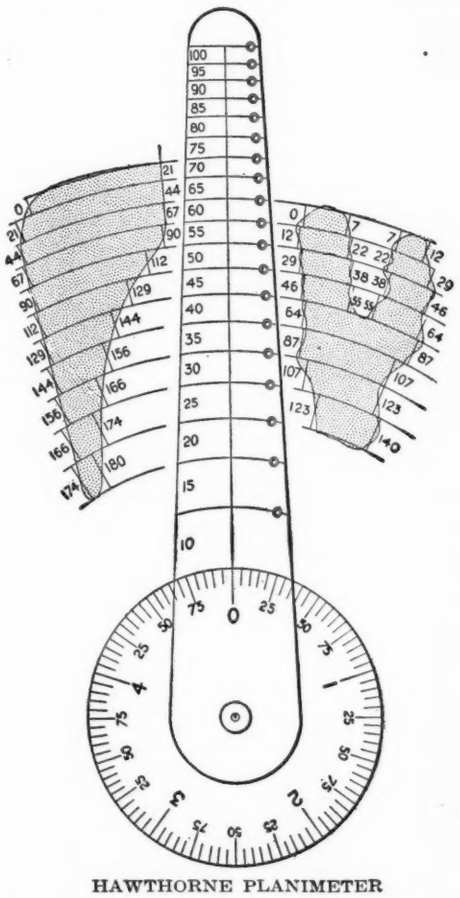
As long as there are combustible gases in the furnace, a reasonable amount of excess air is not serious. The cooling of the flame through moderate air admission above the fuel bed need not be feared. In fact, air must be provided above the grates to complete combustion, because generally, the amount of air admitted through the grates is consumed in the fuel bed. The heat-storing and refracting properties of arches and

piers in the combustion chamber decrease the efficiency of the furnace and have a questionable influence upon the completeness of combustion. The effect of such contrivances must be judged only by their ability to effect or prevent the thorough mixture of air and combustible gases. To achieve this, their location must be at the point of origin of flame development; that is, at or near the bridge-wall. Taking into consideration the fact that the absorption of heat by a surface through direct radiation is decidedly greater than the convection of heating surfaces in contact with the nonilluminant fuel gases, the exposure of the greatest possible amount of heating surface to the luminous flame is of prime importance to the economy of the boiler plant.

Bearing this in mind, efforts must be directed to achieve the desired results with as little refractory brickwork as possible, as otherwise the success in smoke abatement will be gained at the cost of efficiency. This is of greater importance in the hand-fired furnace than in the stoker furnace with continuous feed.

The Hawthorne Planimeter

Most every engineer will be interested in a planimeter that can be carried in the vest pocket and requires but a thumb-tack and a pencil to correctly measure the area of any regular or irregular area. For instance,



HAWTHORNE PLANIMETER

one push of a thumb-tack on an indicator card and the diagram is ready for quick and accurate reading.

The Hawthorne planimeter, manufactured by Hawthorne & Lee, Kinney Building, Newark, N. J., consists of a measuring dial and a transparent arm ruled into a series of numbered concentric ordinates, or circles, of equal area. The total of each is represented by square inches on the dial, any portion of each ordinate being measured directly into square inches by the swing of the arm around the dial.

The illustration shows the application of the planimeter to figures of irregular shapes. To operate, the arm of the planimeter is placed over the figure in such a position that the figure can be divided into a series of concentric ordinates as shown. To measure the area of, say, an indicator diagram, the planimeter is placed in position as shown and fastened in place with a thumb-tack inserted through the eyelet in the disk. The vertical line of the arm is then placed at the zero position on the dial. With a sharp-pointed pencil inserted in the hole on the arm at the ordinate 70, move the arm with the dial to the left until the radial line crosses the line of the figure (at zero) midway on the ordinate. This is done so as to transpose the area projecting outside the line with the unfilled portion of the ordinate.

Then place a finger on the dial to prevent its turning and move the arm to the right until the radial line crosses the boundary line of the figure midway on the ordinate, as at 21, which represents 0.21 sq.in. Then release the dial, place the pencil in the ordinate hole 65 and move the arm and dial to the left line of the figure again. At the proper intersection hold the dial stationary and move the arm only across to the right line of the figure as before. The dial will then read 0.44 sq.in., the total corresponding to the two ordinates 70 and 65. This operation is continued until all the ordinates that embrace the figure have been taken. The total reading of the diagram shown is 1.80 sq.in. area and is read direct from the dial. Reversing the operation insures a check on the first computation.

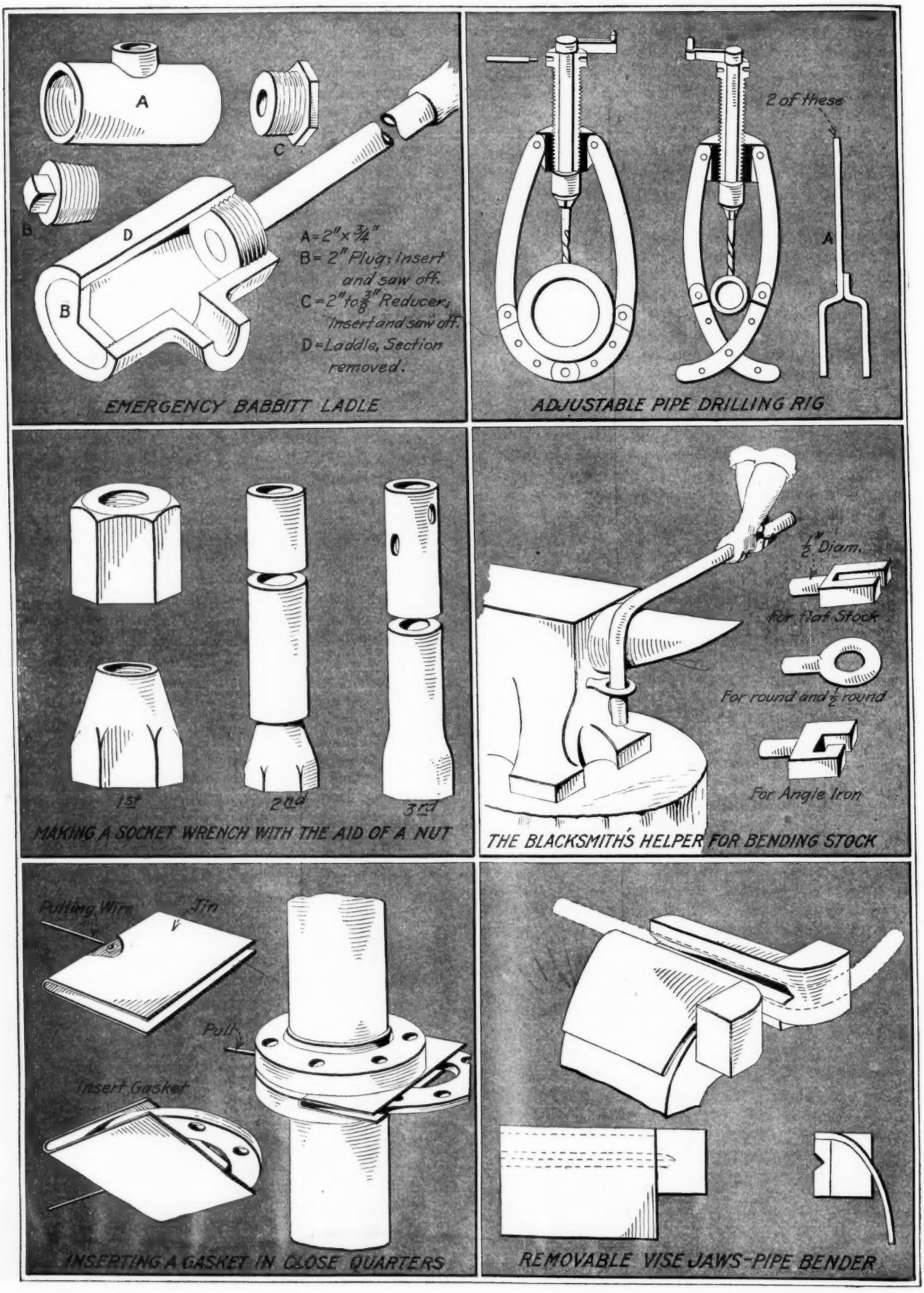
Condenser-Tube Scraper

Numerous methods for cleaning condenser tubes have been described in *Power*, each having found favor with the user. One method is to push or pull a scraper through the tube. This has been improved upon by introducing a stream of water into the tube while using the scraper. The way it is done is as follows: A scraper,

CONDENSER-TUBE SCRAPER WITH WATER SHANK CONNECTION

such as is shown herewith (a manufactured product), is fitted with a $\frac{1}{8}$-in. pipe shank and secured by pinching the pipe tightly against the protruding loop of the scraper end. On the outer end is a 3-in. bushing, in the rim of which three $\frac{1}{8}$-in. holes are drilled equally spaced around the circumference. In the bushing a 3-in. pipe is screwed to the end of which a hose is attached for supplying water. The pipe is, of course, long enough to reach easily through to the back end of the condenser. When the condenser tube requires scraping, the water is turned on and, flowing through the shank, assists in forcing the sludge along with the scraper. The water from the $\frac{3}{8}$-in. holes washes out what deposits remain.

Kinks from an Engineer's Notebook



Editorials

Compound Turbines with Reheaters

THE article by Mr. Hirshfeld on pages 376 *et. seq.* deals with a possible means of improving the performance of a steam turbine which has already received some attention and even application. Its use by Ferranti is described in an interview with the inventor in *Power* of December 30, 1913. A company on the Western coast is preparing to test out the process and exploit it if it proves successful.

The idea is to start with steam of about 700 degrees temperature, whatever its pressure, and to expand it in the first stage only to the dry-saturated condition, then to reheat it to 700 degrees and expand it to the saturation point again and so on until the condenser pressure is reached.

If all the heat could be put in at the higher level, as Mr. Hirshfeld assumes for his typical example, this process would be considerably more efficient than the adiabatic expansion of the uncompounded turbine without reheating; but much of the heat is added at lower levels, which precludes the conversion of so large a proportion of it as though it were all put in at the highest temperature. The amount of heat furnished per unit converted, theoretically, is but little less for the reheating process than for the simpler machine, and the same number of heat units imparted to the steam would produce practically the same amount of work—for the academic case—whether they were used in the ordinary way or by the reheating method. Of the 1358 B.t.u. heat contents of one pound of steam of 365 pounds absolute pressure superheated to 700 degrees F., about 472 would be converted into mechanical energy by adiabatic expansion to one-half pound pressure absolute. If this pound of steam were expanded in three steps or stages with two reheatings—the first to 700 degrees and the second to such a temperature that the exhaust would be dry-saturated—it would convert some 586 B.t.u. But the total amount of heat supplied to it, that is, its original heat content plus the heat added in the reheaters, would be 1678 B.t.u., so that the amount of heat converted per unit of heat furnished is not much greater or the heat rejected to the condenser much less for the reheating than for the simpler system. This for the academic or theoretical case.

For the actual case it may be different. Moisture is a serious drag upon a turbine, its increase to the resistance meaning a lot of power at the high speeds at which turbine rotors revolve. With a given pressure difference, a much less weight of superheated than of wet steam will leak through a given area. Much of the impairment of turbine efficiency by blade erosion is due to moisture in the steam. It is to be expected that a turbine the steam in which is always dry will come nearer to the theoretical performance than one of which the contents are part steam and part water.

But the most attractive possibility of the proposed process lies in the fact that, while it requires practically as much heat as the present process, most of this heat is of so low a temperature that it may be gathered from flue gases and other supplies of heat that would otherwise go to waste. The combination of the turbine and the boiler after the manner of the locomobile in such a way as to return the heat from the uptake to the system in reheated steam might increase the rendition per pound of coal sufficiently to warrant the investment and complication.

Fires in Transformers

INTERNAL fires occasionally occur in large oil-insulated tranformers from one cause or another. Sometimes little damage is done, while at other times the unit on fire is destroyed, and the conflagration spreads to adjoining apparatus and materials, doing extensive damage. The chief source of these fires is of course the large amount of transil oil contained in the unit; this oil burns with a flame that not only is hot, but is difficult to subdue. Compared with the large number of transformers in service, installed and operated under all kinds of conditions, the number of accidents is very small, even though many doubtless occur that never are heard about.

Fires in transformers may result from a number of causes. An arc may occur in the unit, from a short-circuit or from lightning; or the piece of equipment may be overloaded, causing the winding to overheat, char the insulation and vaporize the oil. Then a small spark due to contact between turns sets the oil on fire.

With the large capacity of transformers now in use and the high voltage at which they operate, the problem of caring for the oil in case of fire is a serious one. If the oil in the transformer takes fire, the transformer may be destroyed; on the other hand, if the burning oil escapes from the tank, the matter may be even more serious. The problem, then, that faces everyone operating and installing large oil-filled transformers concerns the precautions to be taken for disposing of the oil in emergencies and for preventing and quenching fires, should they occur. In considering this matter the safety of the attendants as well as that of the transformers and other equipment must be looked after.

When oil-insulated units first came into use, insurance interests and others prophesied many disasters due to the large quantities of oil that is somewhat inflammable. The result was that costly piping systems and isolating

doors and partitions were installed, and pits were built to permit the oil being drained off, should emergency demand. This all increased the cost of the installation, occupied valuable space and served only as a precaution against something that very rarely happened. Moreover, it was found that draining off the oil from a burning transformer was not always the best thing to do. Combustion cannot exist without oxygen; therefore, if the oil is left in the tank, the oxygen present soon becomes exhausted and the fire puts itself out, provided that air is not allowed to enter the tank. On the other hand, draining off the oil allows air to enter the case, which increases the fire; and instead of a quantity of the oil burning on the surface, as the oil level sinks, the transformer windings catch on fire, causing more extensive damage and starting a conflagration that is more difficult to quench.

When a fire starts in a transformer, the endeavor should be to restrict the damage as much as possible; and secondly, to quench it with the least possible delay. The manner of doing this best is open to disagreement, some engineers preferring to do one thing, some another. An article elsewhere in this issue considers this subject from a number of different angles. One of the means suggested for putting out fires in transformers is the use of carbon tetrachloride. This idea is by no means a new one; it has been suggested for use in extinguishing fires in high-speed turbo-alternators and as a substitute for oil, or to mix with the oil in oil switches.

Committee Urges Fuel Economy in New England

A statement urging the practice of economy in the use of fuel by power plants has been issued by the New England Coal Committee, associated with the national defense program. The signers are Charles L. Edgar, president of the Edison Electric Illuminating Co. of Boston; Matthew C. Brush, president of the Boston Elevated Railway; Howard Coonley, president of the Walworth Manufacturing Co., Boston; and A. G. Duncan, H. W. Mason and J. F. McNamara, representing other manufacturing interests and the International Brotherhood of Stationary Firemen. The statement follows:

"Owing to war conditions a most serious situation confronts the coal users of New England during the coming winter. In previous years two-thirds of New England's coal supply was shipped by water in large steamers and barges towed by tugs. Our Government requires every possible ship capable of crossing the ocean and every possible tug for mine sweeping and submarine spotting. Our railroads cannot possibly do this extra work. We must help the Government by saving coal. It is not only an absolute necessity for our own protection, but a patriotic duty. In view of this emergency it is absolutely essential that the utmost economy be used in the burning of coal for power, light and heat, and the New England Coal Committee would urgently call this matter to your attention.

"We do not advocate costly expenditure to make your boiler plants more economical, for owing to the probable delay in furnishing all material for furnishing such improvements, the work could not be completed in time to be of use the coming winter. We do urge, however, that stricter attention than ever be paid to the upkeep and maintenance of existing plants, so that greater efficiency may be obtained therefrom.

"The greatest enemies of efficiency in boiler plants come under two general heads—lack of cleanliness by allowing soot or scale to accumulate on boiler tubes and lack of repairs in allowing leaky brickwork of boiler settings and leaky baffles, and without the expenditure of any great sum of money, marked increase in efficiency may be obtained by giving attention to these simple points.

"Increased economy may also be practiced by closer attention being given to the firing of coal and the number of boilers kept in operation for a given load. It is better economy in general to run fewer boilers at their full capacity than it is to keep in operation a larger number of boilers running underloaded.

"We would urge upon all plants both large and small that accurate daily records be kept of the amount of coal burned and other operating conditions and that these records come under the direct attention of the responsible managers of the plants, who should urge upon their engineers the absolute necessity of the most economical use of coal as a patriotic service.

"We would also urge the hearty coöperation of the men who actually fire the coal. If unable to serve their country by enlisting in its military or naval forces, a few pounds of coal saved by each one every day during the coming winter will in the aggregate amount to enough to send many a ship loaded with supplies for our boys at the front.

"Upon request, the New England Coal Committee will gladly send an inspector to investigate and report on conditions in any plant, charging only a fair price to cover the bare cost of services."

It has been variously estimated that from five to ten million tons of coal is needlessly wasted in this country annually. While this may all be preventable, some of it undoubtedly could be eliminated only through increased expenditure in other directions. However, the larger part could unquestionably be saved through the exercise of intelligent supervision. The second paragraph of the committee's statement does well to urge this point, for probably the large number of small plants are in the aggregate the worst offenders, and in many of these it would hardly pay to install elaborate apparatus, yet closer attention to a few operating details would accomplish much.

Are you saving up to buy that second-series Liberty Bond?

The season's peak of the refrigerating engineer's worries will soon drop to the zero mark.

Correspondence

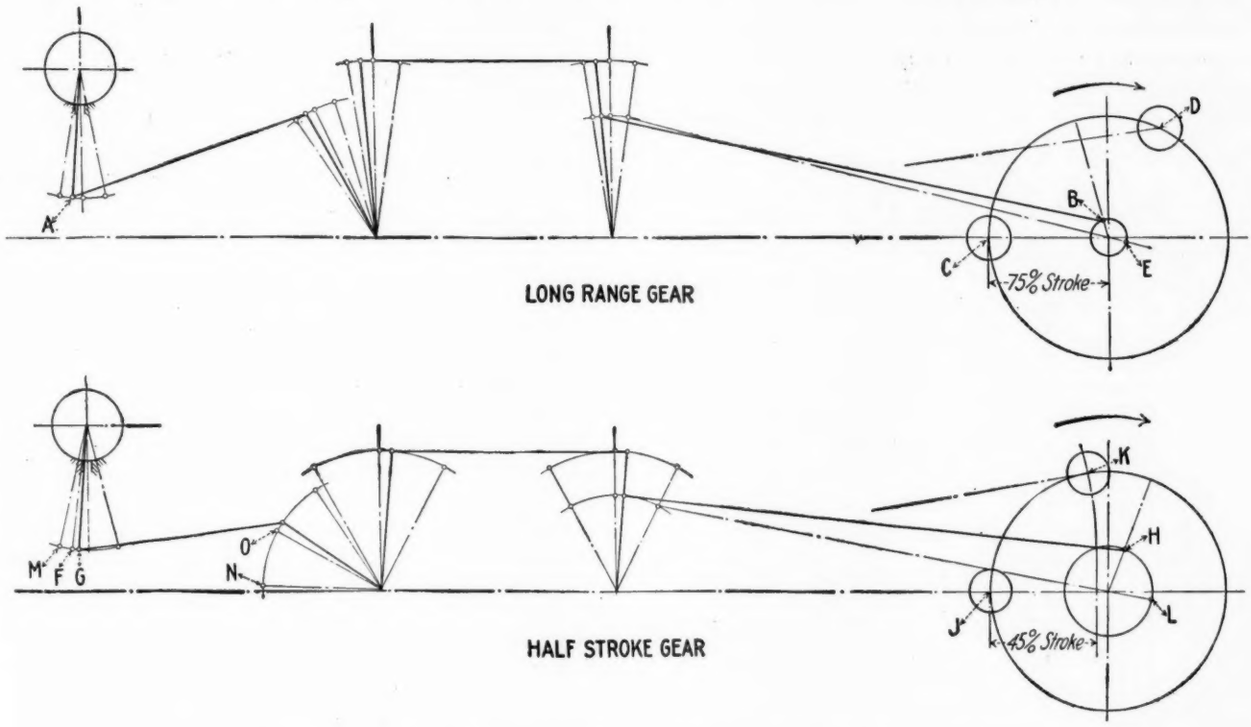
Changing Valve Gear from Short to Long Range

Upon reading the question by L. B. R. and the reply thereto on page 197 in the issue of Aug. 7, it occurred to me that one not thoroughly familiar with the Corliss valve gear might think that any half-stroke gear can be converted into a long-range gear by a few simple adjustments. The subject seems of sufficient importance to warrant more elaborate discussion, so I have prepared two diagrams, one showing the action of the long-range and the other that of the half-stroke gear.

In the long-range gear as usually constructed, the steam lever has about the same travel as the wristplate and in some cases the latter is dispensed with, so that with the engine on dead-center and the steam valve in the lead position *A*, the eccentric at *B* and the crankpin at *C*, it will be seen that the crankpin may move to position *D*, which represents 75 per cent. of the piston travel, while the eccentric is moving to position *E*, which is the point of latest cutoff.

The half-stroke gear is so designed that the steam valve has a lap and the steam lever is at *F*, with the wristplate central. With the engine on dead-center and the eccentric advanced to *H* so that the steam valve may be in the lead position *G* and the crankpin at *J*, it will be seen that when the crankpin has moved to position *K*, which represents 45 per cent. of the piston travel, the eccentric has moved to *L*, which is the latest possible cutoff, unless the radial rods be shortened, as your answer says, so that the wristplate is central, with the valve in the lead position and the lever at *G*, in which case the cutoff will be extended to approximately half-stroke. With a single eccentric gear (not contemplated in your answer, however) this retarding of the eccentric would of course cause late release if the exhaust valves be set to give sufficient compression.

In the half-stroke gear the steam lever moves from *M* to *F* while the wristplate moves half its travel from *N* to *O*. This represents the dead motion of the steam valve and is eliminated in the long-range gear. The long-range gear, having the possible later cutoff, is preferable where heavy overloads sometimes occur. It also has much less wristplate, rocker-arm and eccentric travel and is therefore adapted to higher speed.



DESIGN OF LONG- AND SHORT-RANGE CUTOFF VALVE-GEAR CONTRASTED

Burlington, Iowa. F. P. STODDART.

Thoughtlessness in Power Plants

The article on page 127, July 24, recalled to my mind some carelessness I have seen in power plants by operators who never used their heads. We had an exciter switch which worked horizontally, so that any vertical conductor getting against it would cause a short-circuit. The traveling crane was hand operated by a chain; and one day as it was over the switchboard, "Mr.

Careless" was holding this chain so that it could not touch the board. He let the chain slip from his hands, and it fell across the exciter switch. Out went the breaker, shutting down the plant.

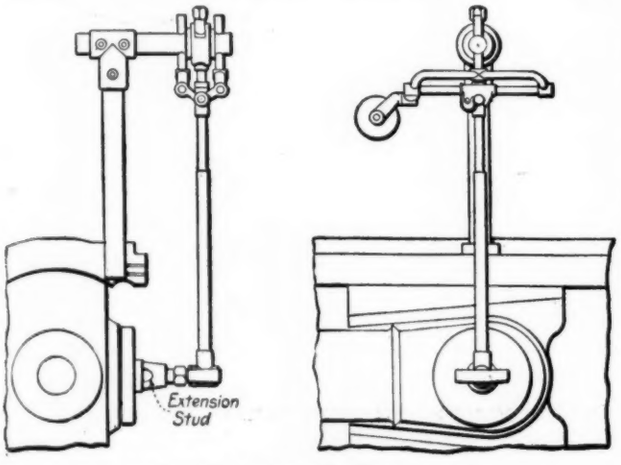
A large motor was run for short periods off the exciter circuit. When this was done, the exciter's circuit-breaker was tied in, for if the motor was started too fast, it would overload and kick out the exciter breaker. The aforesaid "Mr. Careless" was putting this set on in a hurry one morning about 7 a.m., just when the day load was coming on, and forgot to tie in the breaker—out it went and down went the plant again.

One of the feeders to a substation was overloaded, and it was to be temporarily tied in with another on the same board. The power-plant operators were telephoned to to take out the switch at their end until we "got on," so no shock or arc would result. The feeders were tied in all right, but later when the operator notified them to open the switch again, so that the jumper could be taken off, they forgot to do it; and when the jumper was taken off, there was a tremendous flash from which the operator received some bad burns. He was saved from serious injury and possibly the total loss of his eyesight by the smoked glasses he wore, but his eyelashes and eyebrows were singed. The carelessness of the operator at the other end had nearly caused serious injury to this man. W. H. NOSTON.

Philadelphia, Penn.

Telescopic-Oiler Discussion*

In my letter under date of Apr. 3, disapproving of telescopic oilers for crosshead pins, I based my objection on the performance of two oilers, used on a cross-



SIDE AND FRONT VIEW OF OILER

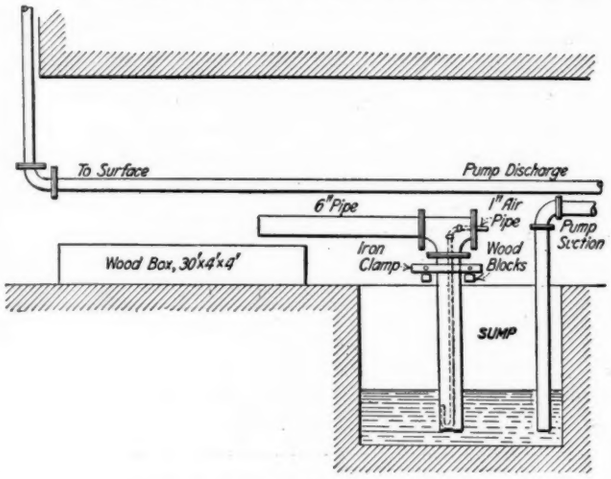
compound engine, that are not giving satisfaction. These oilers were installed about one year ago and were bought of a manufacturer of high-class apparatus at a cost of $30 each. The illustration shows their general design. The bottom swivel joint is a taper fit and is held together by a band spring; it throws oil. The top connection rocks on a supporting stud through which an oil tap is connected. The pumping action of the oiler forces the oil out at the top. The upper telescopic tube has two small holes drilled in it to prevent the formation of a vacuum—but they don't. The oilers are fed by a sight feed and the make-and-break of the vacuum is so strong that oil will not drop in the sight feed as the drop is pulled off by the vacuum and is blown up the walls of the sight glass, from which it drains to the crosshead pin and the floor. J. B. WALKER.

Ninety Six, S. C.

*See "Power," p. 707, May 22, and p. 748, May 29, 1917.

Sump-Cleaning Device

Being an engineer at the iron-ore mines in Michigan, I have taken a great interest in reading the articles in *Power* of late, entitled "Tom Hunter, Hoisting Engineer." I wish to make a reply to the article in the July 17 number, page 79, where Fig. 2 shows a sump baffle



CLEANING SUMP WITH AIR LIFT

and cleaning-out tunnel. This is a very good arrangement for cleaning the sump, but I have never seen anything like it and doubt if there are many mines that would go to the expense of such a way of cleaning the sump.

The accompanying illustration shows a simple device that is often used in the iron mines for cleaning the sump. It is made up, as shown, with a 6-in. tee and a piece of 6-in. pipe that is lowered into the sump; another 6-in. pipe extends to a settling tank. The pipe extending to the sump has a 1-in. air pipe (it may be on either the inside or the outside) that extends close to the bottom end, with an upward bend. On the top it is connected with an air hose carrying about 70 lb. pressure.

When the sump needs cleaning, the covering over the sump is removed; two pieces of 4 x 4-in. wood are placed across and the suction pipe lowered near the bottom of the sump. A clamp is fastened tight on the pipe close to the tee and resting on the 4 x 4-in. pieces, holds the pipe in position. With the discharge extended to the settling tank and the air hose attached, it is ready for operation.

When the air pressure is turned on, it causes the water and ore to rush up the pipe and over into the tank, where the heavy ore will settle to the bottom and the water will overflow at the top. After a few minutes the clamp is moved along on the timbers to another position to bring the suction in contact with more ore to be drawn out. A device of this kind will clean a large sump in a very short time.

Norway, Mich. THOMAS J. PASCOE.

Smoke Abatement Means Economy

In Mr. Henderson's letter on page 127, in the issue of July 24, the estimated saving of $200,000,000 per year is rather modest. Twice as much would be more nearly correct, I believe; and this can be accomplished without extra investment except a little brains and—by Federal regulation.

Railroads and various industries waste from 10 to 15 per cent. of their fuel. Smokestacks belching forth tar vapor and free carbon may be a pretty sight to some, but they are sure signs of ignorance or wanton waste. What is the cause of this, and why should it be tolerated? It may be ignorance, but I can hardly conceive of this being possible.

The price of coal is going up, and it is the popular pastime to abuse coal dealers and coal producers and parade them as a trust or combination of hold-up men and robbers; but are they? No; they simply do not know the worth of their ware. Few realize the true worth of coal. Being the principal source of energy, it is the soul of all human activity. Man, a heat engine hmself, cannot exist without heat and, therefore, the worth of coal is on a par with that of the human life.

Nature in her infinite wisdom buried coal deep in the ground to preserve the precious treasure; but nature has failed, and we are wasting coal without measure. The coal supply, being a measurable quantity, is limited. No matter how long it may last, there will be an end; it belongs to no one except to sustain life.

The price of coal is of no importance, but the coal itself is the important consideration; let the price go higher and higher until it compels a common-sense usage. Coal-price boosters do more toward conservation than any amount of talk, and those now branded as robbers are human benefactors in disguise, however perfect the disguise now appears.

Government supervision—yes, in time of war and peace. The nation certainly has a right to regulate the use of this limited commodity.

Chicago, Ill. H. MISOSTOW.

The Training of Operating Engineers

I am very much interested in the subject of training operating engineers and the discussion of this subject by James A. Pratt in the issue of July 17, page 95 (see also editorial, June 12, and page 196, Aug. 7). No one can seriously question the desirability of such training for operating engineers as will enable them to speak and write intelligently, but I fail to see the relative value of many of the subjects mentioned as typical for a course for operating engineers. It would be interesting to know how many students are attracted to such a course and whether those who complete it follow the steam engineer's job for a living. Unless some of the work mentioned as "shop" has to do with the practical side of operating, the student does not get much of an idea of what power-station operation is during the first year. In fact, the subject of "Steam" is not mentioned until the end of the third year and it is then coupled with "Gas" and "Electricity" and only 1½ hours per week are given to the three subjects from Sept. 1 to Apr. 1. One would have a fair knowledge of history, grammar, literature and music with a total of eighteen hours per week in four semesters' work, but is 1½ hours of "steam" sufficient for a practical course for operating engineers?

I do not wish to undervalue the advantage of thorough training in the so-called "cultural" subjects, but it is my idea that the cultural work may be put right in with the practical work. Students should be taught the correct use of English while they are studying steam boilers, electricity, etc. The trouble is that we too often consider the study of English as a thing apart; and as a result, the student does not know how to make use of what he knows about it. When teaching a class in power-plant operation, I encouraged the students to write of their practical experiences for publication, and some were accepted by the editors. Can a better or more practical demonstration of the combination, good English and the knowledge of technical subjects, be imagined? It is a matter of gratification to me to know that some of the students who started the habit then are keeping it up.

When connected with the Iowa State College, I started a two-year course for electrical workers and stationary engineers under the direction of the college authorities. It was intended for students who had passed the eighth grade and were at least 17 years old. The schedule of studies is given in the hope that it will bring forth further discussion and constructive criticism.

SCHEDULE OF STUDIES

Two-Year Course for Electrical Workers and Stationary Engineers

First Year

First Semester	Periods	Second Semester	Periods
Elementary Chemistry	2	*Letters and Themes	3
*Letters and Themes	3	*Algebra or Plane Geometry	4 or 5
*Shop Mathematics or Algebra	4 or 5	*Shop Drawing	2
*Shop Drawing	2	Pattern Work	1
Wood Shop Work	1	*Steam Boilers	3
Foundry Work	1	Gymnasium Work	R
Gymnasium Work	R	*Elementary Electricity and Magnetism	3
Elementary Physics	3		
	16 or 17		16 or 17

Second Year

Third Semester	Periods	Fourth Semester	Periods
Wiring Diagrams and Problems	2	Dynamo Practice	2
Direct and Alternating Current Machinery	3	Practical Experience	R
Practical Wiring	2	*Trigonometry	5
*Plane or Solid Geometry	3 or 5	Machine-Shop Work	2
*Shop Sketching	2	*Heating and Sanitation of Buildings	4
Machine-Shop Work	1	Power-Plant Operation	4
Pipe Fitting	1	Gymnasium Work	R
*Gas Engines	2		
Gymnasium Work	R		
	16 or 18		17

R Indicates that the study is required without credit. * May betaken by correspondence.

In the opinion of readers, is this schedule suitable for the purpose and what improvements are suggested?

Erie, Penn. R. B. DALE.

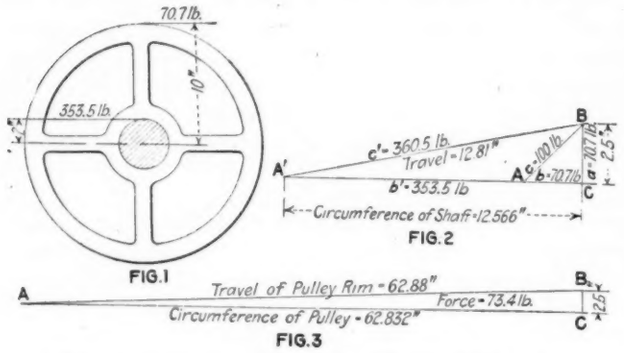
Why Twist the Pulley?

I offer the following as a solution of the question, "Why is it that, in forcing a pulley on a shaft, you can gain by twisting the pulley?" asked by Sidney A. Reeve in the issue of June 12, page 808.

As an example, take a pulley 20 in. diameter to be forced on a 4-in. shaft. Suppose the resistance to slipping on the shaft is such that when a force of 100 lb. is applied at the rim of the pulley in a direction which makes an angle of 45 deg. to the axis of the shaft—that is, as much force is applied to rotating the pulley as to slipping it on the shaft—it will just turn and will gradually advance upon the shaft as it is being rotated.

This force of 100 lb. applied at an angle of 45 deg. to the axis of the shaft will give 70.7 lb. acting in a direction to rotate the pulley and 70.7 lb. acting in a direction parallel to the shaft tending to slip it upon the shaft (100 × cos 45 deg. = 70.7 and 100 × sin 45 deg. = 70.7).

The force of 70.7 lb. acting in a direction parallel to the axis of the shaft will give just that much force tending to slip the pulley upon the shaft, but the force of 70.7 lb. applied at the rim of the pulley acting at right angles to the shaft will be multiplied 5 times at the shaft where the resistance acts, therefore overcoming 5 × 70.7 lb. = 353.5 lb. resistance at the circumference of the shaft, because the force has 5 times the leverage acting from the shaft center that the resistance has, as shown in Fig. 1.



FIGS. 1, 2 AND 3. ANALYSIS OF ROTATING AND AXIAL FORCES

Fig. 1—Pulley forming basis of calculation. Fig. 2—A diagram of the forces involved. Fig. 3—Travel of a point on the pulley rim and component of forces.

For equilibrium to exist, the force times its lever arm must equal the resistance times its lever arm, so that in this case we have 70.7 lb × 10 in. = 707 and 353.5 lb. × 2 in. = 707, both moments being equal; therefore the forces acting at the circumference of the shaft are 353.5 lb. acting circumferentially and 70.7 lb. acting axially.

Fig. 2 is a diagram of these forces showing their magnitude and the direction in which they act. The force AB, or C = 100 lb., is the force that is applied at the rim of pulley, and the horizontal and vertical components of this force, or each 70.7 lb., the force a = 70.7 lb. acting from C to B being parallel to the shaft and the force b = 70.7 lb. acting from A to C acting circumferentially. However, this is acting at the rim of pulley and is multiplied 5 times making b' = 353.5 lb. acting from A' to C at the circumference of the shaft. The combined forces acting at the circumference of the shaft = $\sqrt{353.5^2 + 70.7^2}$ = 360.5 lb., which is the force acting from A' to B tending to turn the pulley on the shaft. The force of 100 lb. applied at the pulley rim will overcome a resistance of 360.5 lb. at the surface of the shaft in the direction $A'B$, so that in rotating the pulley one revolution, a point on the pulley hub in contact with the shaft will move around the shaft along a line $A'B$ and will advance on the shaft a distance CB = 2.5 in., which is found by the following proportion:

Circumferential force at the shaft is to circumference as force acting parallel to the shaft is to distance the pulley is advanced on the shaft, or 353.5 lb.: 12.566 in.:: 70.7 lb.: distance. Therefore distance = $\frac{12.566 \times 70.7}{353.5}$ = 2.5 inches.

Diagram Fig. 3 shows the direction of travel of a point on the rim of pulley and the component of the applied force (100 lb.) acting in that direction.

The component of the applied force acting in the direction AB, Fig. 3, is a little different from what we found to be acting at right angles to the shaft (70.7 lb.) because of the small angle A. Angle A is found as follows:

$$Tan\ A = \frac{2.5}{62.832} = 0.03978$$

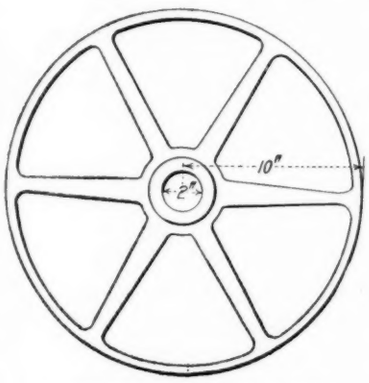
and the corresponding angle is 2 deg. 17 min. The component of the applied force acting in the direction AB is then found to be 100 lb. × cos (45 deg. — 2 deg. 17 min.) = 100 lb. × cos 42 deg. 43 min. = 73.4 lb., giving the following equation of moments. The component of the applied force at the pulley *rim* (Fig. 3) acting in the direction of the travel times the distance traveled equals the force at circumference of *shaft* (Fig. 2) times distance traveled, or

73.4 lb. × 62.88 in. = 360.5 lb. × 12.81 in.
4618 = 4618

Seattle, Wash. H. G. ROBERTS.

Consider a pulley having a diameter of 20 in. and a hub 6 in. long forced on a shaft 2 in. diameter. Assume that the hub grips the shaft with a bearing pressure of 20 lb. per sq.in. The total force with which the pulley grips the shaft is therefore 20 × 6 × π = 754 pounds.

To remove the pulley from the shaft a person would have to exert a pull of over 754 lb. in order to make the pulley slide along the shaft. This would necessitate the use of some mechanical means such as a clamp and screw. On the other hand, the resisting moment offered against turning the pulley about the shaft is the product of the total bearing pressure, 754 lb., times the radius of rotation, which is 1 in. (the radius of the shaft, Fig. 1) 754 × 1 = 754 in.-lb.



PULLEY TO GO ON SHAFT

By applying a suitable force at the rim of the pulley, we can overcome this resisting moment and cause the wheel to turn on the shaft. This force must be equal to $\frac{754}{10}$ lb., or 75.4 lb., where 10 is the radius of rotation of this force about the shaft center in inches. A person can grip the rim with both hands and by exerting a pull or push of 38 lb. with each hand, can make the wheel turn without mechanical means.

While the pulley is being turned on the shaft, it can be forced along the shaft so that the hub will travel in the path of a helix and it takes a smaller pull to keep a load moving after it is once started, than it takes to start the same load from rest. DAVID FLIEGELMAN

Bridgeport, Conn.

Inquiries of General Interest

Purpose of Cylinder Counterboring—What is the primary purpose of the counterbore of an engine cylinder?

W. A. M.

The primary purpose of the counterbore is to permit the piston to override the ends of the main bore and thus leave no portion of the bore unworn with formation of shoulders at the limits of travel of the piston.

Formula for Calculating Heat Value of Coal—What is the formula for calculating the heat value of coal from the percentages of carbon, hydrogen, oxygen and sulphur shown by analysis? R. L. W.

The heat value, or number of B.t.u., developed by complete combustion of one pound of the given fuel is obtained by the formula,

$$B.t.u.\ per\ pound\ of\ the\ fuel = 146C + 620\left(H - \frac{O}{8}\right) + 40S$$

in which C, H, O and S are respectively the percentages of carbon, hydrogen, oxygen and sulphur present.

Objections to Oversized Reducing Valve—What are the objections to the use of a larger steam-pressure reducing valve than necessary for supplying the maximum amount of flow required? R. E. A.

In most forms of reducing valves, the valve lift is small, and the larger the valve the less will be the lift for a given rate of flow. Consequently, when the valve is used below its capacity, it is not capable of effecting close differentiation of pressures and there will be greater wiredrawing of the steam and erosion of the valve seat.

Dampening Pulsations That Affect Pump Regulator—How can an electric self-starting attachment for a triplex pump be protected from vibration due to water-hammer in the pipe connections? E. E. F.

The pulsations should be dampened by throttling the pressure connection to the starting attachment, thus requiring more time for the changes of pump pressure to effect a change in the volume of water contained by the starting attachment. The pressure can be further equalized by the employment of a small air chamber on the pressure pipe connection to the attachment between the throttling valve and the regulator.

Negative Slip of Boiler-Feed Pump—May not a boiler-feed pump deliver more water than would be represented by the piston or plunger displacement of the pump?

W. C. K.

Negative slip or discharge of a pump in excess of the piston displacement is not likely to occur unless there is a long suction pipe and long stroke of pump, with discharge taking place against comparatively low pressure that is overcome by the ram-like action of the suction water. Therefore the conditions favorable to negative slip are rarely if ever present in the operation of ordinary boiler-feed pumps.

Inches of Vacuum Shown by Indicator Diagram—How is the number of inches of vacuum computed from the diagram of a condensing engine? J. N. R.

Inches of vacuum is the number of inches of mercury column pressure less than the pressure of the atmosphere, and as one inch of mercury column pressure is equal to 0.491 lb. per sq.in., the equivalent inches of vacuum shown at any part of the diagram would be the length of the ordinate of the point below the atmospheric line multiplied by the scale of the indicator spring and divided by 0.491. The number of inches of vacuum thus shown for any point of the diagram, or the average vacuum of the whole diagram, must be less than the inches of vacuum made by the condenser on account of the higher temperature of the engine cylinder and the throttling effect of the exhaust passages and connections to the condenser.

Loss of Draft Through Boiler—In the operation of horizontal return-tubular boilers, what should be the drop between the force of the draft in the front smoke connection and the furnace space over the fire? L. B. R.

In ordinary return-tubular settings, operated with sufficient draft for the combustion of 20 to 25 lb. of coal per square foot of grate per hour, the draft available at different parts of the setting, expressed as a percentage of draft at the stack side of a damper in the smoke uptake, is about 70 per cent. in the front smoke connection, 48 per cent. in the rear combustion chamber, and 44 per cent. in the furnace space over the fire. Thus, if the force of draft on the stack side of the damper in the smoke uptake is 0.6 in. of water, the drop between the draft in the front smoke connection and the furnace space over the fire should be about $0.6 \times (0.70 - 0.44) = 0.156$ in. A greater drop would indicate unusual obstruction in the draft passages of the boiler or setting.

Negative Steam-Engine Indicator Diagram—What is a negative steam-engine indicator diagram, and how is a negative diagram to be included in estimating the power developed by an engine? F. C. K.

When the average pressure acting on one side of the piston of an engine during the forward stroke is less than the average back pressure acting on the same side of the piston during its return stroke, the mean pressure will represent resistance to the motion of the piston, or negative energy, and therefore the diagram is said to be negative. Such a diagram is obtainable when the steam supply is very small or the amount of steam or air present at the beginning of the stroke is so small that the average pressure during expansion is less than the average back pressure during the return stroke. As a negative diagram represents resistance in opposition to the forward motion of the engine, then, in estimating the power developed, the value of a negative diagram obtained on one side of the piston is to be deducted from the power developed on the other side.

Airbound Water Pipes—What causes a water-supply line to become airbound and how can the trouble be remedied?

A. M. V.

Water-supply lines become airbound from liberation of air out of the water at places in the line where there is a reduction of the pressure. Hence the trouble is more likely to occur at crests or points in the line where the character of the flow is productive of cavitation. Liberation of air is more likely to occur at warmer temperatures. It generally forms aggregations of small bubbles that become attached to the sides of the conduit and obstruct the flow of water. When such an accumulation of air completely fills a section of the pipe line, the bubbles form an obstruction like a plug of elastic packing, that for its movement may require more than the available head pressure. A slug of air bubbles in a pipe line can usually be dislodged by striking the pipe a few sharp hammer blows combined with unbalanced pressure on opposite sides of the slug or by simply opening an air-cock in the pipe near the point where the air bubbles have accumulated. Pipe lines can usually be kept from becoming airbound by leaving a small opening on the upper side of the pipe at high points in the line. If the resulting waste of water is objectionable, the trouble can be prevented at such a place by maintaining a vertical open vent pipe, connected out of the top of the line and raised higher than the head of the supply.

Ten More Forest Battalions Authorized

The formation of a second "Forest" regiment comprising 10 battalions and composed of lumbermen and woodsworkers who will go to France and get out of the forests materials for the use of the American, French and British armies, has been authorized by the War Department. Two battalions are to be raised at once with the active aid of the Forest Service of the Department of Agriculture. It is expected that the remaining eight battalions will be called for in a short time. Nine "service" battalions, made up of laborers who will be used in connection with the Forest regiment, have also been authorized, and two battalions have been ordered raised at once.

To provide for future contingencies it has been decided to commission at the present time enough officers for other battalions yet to be raised. Those men not needed now will be placed on the reserve and called as the other units are formed. According to the present plan, 50 per cent. of the officers will be sawmill and logging operators, 25 per cent. will be technical foresters and 25 per cent. will be men with military training. A number of the graduates of the engineer camps have been selected for service with the new units.

A considerable number of captains and lieutenants is to be selected in the immediate future. The minimum age limit for commissioned officers has been set at 31.

A first regiment of woodsmen numbering about 1200 men and designated as the Tenth Engineers (Forest) has already been recruited and assembled and is being trained at American University, D. C. This regiment was raised at the request of the British Government to undertake the production in France of cross-ties, bridge, trench and construction timbers, mine props, lumber and other forms of wood required in connection with its military operations. The landing of the American expeditionary forces has made necessary similar provision for their needs, while the French military authorities have indicated that some of the work incidental to their operations might be taken over by woodsmen from this country. Decision to raise the new and much larger force has followed a study of the field of possible usefulness to the allied cause, made by American foresters attached to General Pershing's staff.

Each of the 10 battalions of the second regiment will comprise three companies of 250 men each, and will be under the command of its own major. The regiment will be made up of volunteers. Applicants must be white and between the ages of 18 and 40. Skilled lumberjacks, portable-mill operators, tie cutters, logging teamsters, camp cooks, millwrights and charcoal burners are among the classes of men desired.

Submarine Base Power Plant at New London

The Bureau of Yards and Docks, Navy Department, Washington, D. C., has advertised for proposals for equipment for the new power plant at the submarine base, New London, Conn. The Government will furnish the building necessary for the installation of the equipment, and the entire plant is to be completed and ready for service not later than Feb. 1, 1918. The equipment will include:

From 2000 to 3000 hp. of water-tube boilers with settings arranged for coal burning. The boilers to be designed for operation at 200 lb. per sq.in. gage pressure and equipped with superheaters of an approved type to produce at least 100 deg. superheat, each unit to have not more than 10,000 nor less than 6000 sq.ft. of heating surface. It is the intention to operate these boilers immediately with fuel oil, and the furnaces are to be equipped with oil burners of suitable size and type. Boilers and accessories shall comply with the requirements of the A.S.M.E. Code.

Two 40-gal. per min. duplex double-acting fuel-oil pumps and heaters, steam pressure 200 lb. per sq.in. gage, 100 deg. F. superheat, fuel-oil burner pressure up to 50 lb. per sq.in. gage. Two centrifugal turbine-driven boiler-feed pumps to deliver 400 gal. per min. at a temperature of approximately 210 deg. F. against a pressure of approximately 240 lb. per sq.in. gage, to be driven by turbines operating on steam at 200 lb. per sq.in. gage, 100 deg. superheat and exhausting against a back pressure of 25 lb. per sq.in. gage.

Two open feed-water heaters, each capable of raising the temperature of not less than 60,000 lb. of water per hour from 80 deg. to 210 deg. F. Two centrifugal turbine-driven heating-system pumps to deliver 2000 gal. per min. of water at temperature up to 250 deg. F. and pressures up to 125 lb. per sq.in. gage.

Two or three turbo-alternators, each of approximately 1875-kv.-a. capacity at 80 per cent. power factor, equipped with bleeder-type turbines operating on steam at 200 lb. per sq.in. gage pressure and 100 deg. F. superheat, the alternators to deliver current at 2300 volts 60-cycle three-phase.

Two or three surface condensers, each to condense at least 27,000 lb. of steam per hour at 28½ in. vacuum when supplied with cooling water at not more than 60 deg. F. Two centrifugal turbine-driven hot-water pumps of 150 gal. per min. capacity against a head of 125 lb. per sq.in. gage. Two hot-water service heaters, each capable of heating 75,000 lb. of water per hour from 40 deg. to 180 deg. F. Two steam-turbine-driven double-inlet, double-width, induced-draft fans, each capable of exhausting 150,000 cu.ft. per min. of flue gases. Two centrifugal turbine-driven combination fire and circulating pumps, each capable of delivering on fire service 2500 gal. per min. of sea water against a head of 400 ft. and on circulating service 5000 gal. per min. against a total head of 50 ft. Two centrifugal turbine-driven circulating pumps, each capable of delivering 5000 gal. per min. of sea water against a head of 50 ft. Two centrifugal turbine-driven condensate-return pumps, each capable of delivering 100 gal. per min. against a head of 40 lb. per sq.in. gage.

A sectional cast-iron condensate tank of 350 cu.ft. capacity. One multiple-stage vertical air-compressor set, to compress 50 cu.ft. of air per hour at 3500 lb. per sq.in. gage. A horizontal air receiver of 200 cu.ft. capacity. Two horizontal turbine-driven rotary wet-air condenser pumps. One 20-ton traveling crane equipped with three induction-type motors wound for 200 volts a.c. Two cast-iron 25 x 48-in. wedge-type sluice gates, two sets of screens and guides for pumphouse intake, and a 5-ton monorail hoist.

The Interboro Contracts

An agreement between the Interborough Rapid Transit Co. and the New York Municipal Railway Corp. and the New York Consolidated Railroad Co., under which the first-named company will sell power to the two others for the operation of the new rapid-transit lines of the Brooklyn system in Manhattan, provides for a revision of the prices paid for current in the event that the demands of the Brooklyn companies vary from expectations and also in the event that the price of coal varies from $3.23 per gross ton.

This provision of the contract says that the kilowatt-hour charges—0.285c. for direct current and 0.7c. for alternating current—shall be subject to increase or decrease to conform to any increase or decrease in the basic cost of coal, as compared with the original basic cost upon which such charges were determined; namely $3.23 per long ton of 2240 lb., containing 14,250 b.t.u. per lb. of dry coal, f.o.b. alongside power-house pier. The revised cost of coal per kilowatt-hour shall be determined by multiplying the cost of coal per kilowatt-hour at the substation bus, including a profit of 0.31c. for direct current and 0.29c. for alternating current, which was used for determining the kilowatt-hour charges, by the ratio of the original basic cost to the new basic cost of coal for direct-current and alternating-current electrical energy respectively, both expressed in basic B.t.u. per dollar. The difference between this figure and the cost of coal per kilowatt-hour at the substation bus—0.31c. for direct-current and 0.29c. for alternating-current—used in determining the kilowatt-hour charges as previously stated shall be added to or subtracted from the kilowatt-hour charges for direct-current and alternating-current electrical energy respectively, until there is another change in the basic cost of $3.23 per long ton of coal.

There is also an agreement between the Transit Development Co., the New York Municipal Railway Corp. and the New York Consolidated Railroad Co., all three being Brooklyn Rapid Transit associated companies, under which the Transit Development Co. will furnish the power for the operation of all rapid-transit lines in Brooklyn. This agreement provides that the revised cost of coal per kilowatt-hour for any year shall be determined by multiplying the cost of coal per kilowatt-hour at the point of metering which was used in determining the kilowatt-hour charges for direct-current and alternating-current electrical energy —namely, 0.285c.—by the ratio expressed by the fraction of which the numerator will be the average B.t.u. per dollar obtained during the year 1916—namely, 10,860,000 B.t.u. —and of which the denominator will be the average B.t.u. obtained during that year; and the difference between the product resulting and the figure of 0.285c. shall be added to or substracted from the kilowatt-hour charges for direct-current and alternating-current electrical energy respectively, as the case may require for that year.

It is estimated that the annual demands for current for the first year of the agreement (Dec. 1, 1917, to Dec. 1, 1918), which has ten years to run, will be about 46,900,000 kw.-hr. This estimate of demand increases yearly and amounts to 118,800,000 kw.-hr. for the year ending Dec. 1, 1927. The estimated requirements for high-tension alternating-current energy for signals and lighting for the year 1917-18 are 4,235,000 kw.-hr., and for the final year of the ten-year period 6,902,000 kilowatt-hours.

For direct current to be used for traction purposes the contract with the Interborough Co. calls for payment of 8.25 mills per kilowatt-hour and for the alternating current at 7 mills per kilowatt-hour.

The contract with the Transit Development Co., which company assumes the task of furnishing the Brooklyn Rapid Transit elevated lines in Brooklyn with power, provides that for a period of ten years to begin not later than Dec. 31, 1919—when the Transit Development Co. shall have completed the installation of two large, modern units—that company will stand ready to furnish the New York Consolidated Co. all the direct and alternating electrical energy required for the maximum operation of rapid-transit railroads in Brooklyn. For the first six years of the contract period all direct current shall be furnished at one cent per kilowatt-hour, and all alternating current at 9 mills per kilowatt-hour. For the last four years of the period the price of direct current shall be 9.9 mills and for alternating current 9 mills per kilowatt-hour.

Imprisoned in a Boiler

It is not often that a man becomes imprisoned in a steam boiler, but that is what happened to John Garvey, a fireman, on the evening of Sept. 4, at the Union League Club, 39th St. and Fifth Ave., New York City. Before the prisoner

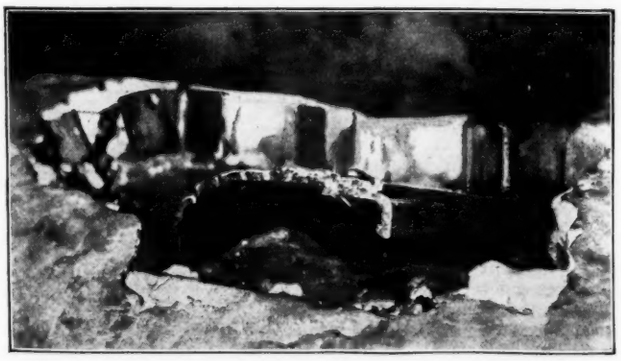


FIG. 1. CUT PORTION OF PLATE AND MANHOLE RING

was released, a portion of the manhole ring and the boiler shell was cut out by means of an oxyacetylene flame.

Garvey had been sent into the 16-ft. return-tubular boiler to remove scale from the heads. When he wanted to get out, he could not. When he realized that apparently his body was larger than the manhole, he became excited which added to his difficulty. Naturally, a frightened person loses all sense of judgment, and it is a fact that under such circumstances a man is sometimes unable to get out of a hole that he a short time before entered.

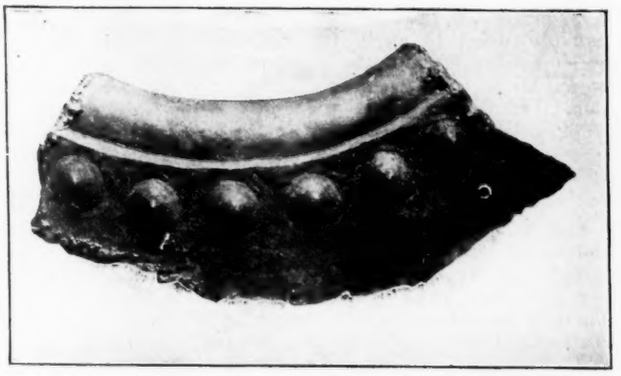


FIG. 2. SECTION OF RING AND PLATE REMOVED FROM BOILER

The manhole was of the ordinary size, but when Garvey's hips came to it his progress was stopped. Next he was told to remove his clothing and smear himself with grease. This was done, and he was dragged halfway through the manhole three times, but stuck when his hips came to the reinforcing ring. As a last resort the rescue squad of the fire department was sent for and arrived with an oxyacetylene gas apparatus for cutting out the manhole ring.

The result of the job is shown in Figs. 1 and 2. The former shows the bricks removed from around the manhole and where the section of ring and boiler plate was removed. The latter shows the shape of the cut-out portion.

The job was a bungle from a mechanical point of view because, instead of cutting the ring all the way around even with the edge of the hole in the boiler plate, which would have made the opening at least 4 in. larger all the way around, a section about 16 in. long by 6 in. wide at its greatest measurement was cut out of the ring and boiler plate, the cut extending toward the back end of the boiler.

Just what repairs will be made has not been determined, but it would appear that a new plate will be necessary, or a patch at least sufficiently large for making a new manhole opening.

Had the imprisoned man been in any danger, the method pursued would have been perfectly justified, but under the circumstances a perfectly good boiler was partly ruined.

The chief engineer of the plant was not consulted and knew nothing of what was taking place. To describe his feelings when he viewed the work the next morning is beyond words.

Urgent Needs of the Ordnance Department of the Army

The United States Civil Service Commission announces the following open competitive examinations for positions in the several ordinance establishments of the War Department or in or under the office of the Chief of Ordnance, War Department, Washington, D. C. The salaries named are for entrance:

Mechanical engineer, artillery ammunition $3000 to $3600 year; mechanical engineer, experimental work, $2500 to $3000 year; mechanical draftsman, $1000 to $1400 year; apprentice draftsman, $480 year; inspector of artillery ammunition, $1500 to $2400 year; inspector of field-artillery ammunition steel, $1500 to $2400 year; assistant inspector of field-artillery ammunition steel, $3.50 to $5 day; inspector of ammunition packing boxes, $3.52 day to $1800 year; inspector and assistant inspector of powder and explosives, $1400 to $2400 year; inspector of ordnance equipment, $1500 to $2400 year; assistant inspector of cloth equipment, $80 to $125 month; assistant inspector of leather, $100 to $125 month; assistant inspector of small hardware, $80 to $125 month; assistant inspector of textiles, $80 to $125 month;

assistant inspector of leather equipment, $100 to $125 month; clerk qualified in business administration, $1200 to $1500 year; index and catalog clerk, $1000 to $1200 year.

The examination for index and catalog clerk is open to both men and women; the other examinations are open only to men. The government urgently needs men for the work indicated, and qualified persons are urged, as a patriotic duty, to apply for examination. Until further notice applications for the positions named will be received at any time by the United States Civil Service Commission, Washington, D. C. Papers will be rated promptly. Applicants will not be required to appear at any place for examination, but will be rated principally upon the elements of education, training and experience, as shown by their applications and by corroborative evidence.

Full information concerning examinations, application blanks, etc., may be obtained by calling in person upon the secretary of the local board of civil service examiners at the post office in any city in which city delivery of mail has been established, or by communicating with the United States Civil Service Commission, Washington, D. C.

Army Cantonment Construction

Col. I. W. Littell, in charge of the cantonment construction for the United States Government, authorizes the following:

With the arrival of the first contingent of the new National Army at the cantonment Sept. 5, the status of construction at the various cantonments will undoubtedly be of public interest.

Altogether, 16 military cities have been built by the Government to house the 687,000 citizen soldiers selected for service by the draft. Seven are ready to receive their entire quota of officers and enlisted men. These are Camp Taylor, at Louisville, Ky.; Camp Travis, at Fort Sam Houston, Tex.; Camp Lee, at Petersburg, Va.; Camp Lewis, at American Lake, Wash.; Camp Sherman, at Chillicothe, Ohio; Camp Devens, at Ayer, Mass.; and Camp Grant, at Rockford, Ill. Seven other cantonments are ready to receive all the officers and two-thirds or more of their entire quota of enlisted men. These comprise Camp Dodge, at Des Moines, Iowa; Camp Funston, at Fort Riley, Kan.; Camp Custer, at Battle Creek, Mich.; Camp Pike, at Little Rock, Ark.; Camp Dix, at Wrightstown, N. J.; Camp Jackson, at Columbia, S. C.; Camp Gordon, at Atlanta, Ga. The two remaining cantonments—Camp Upton, at Yaphank, Long Island, and Camp Meade, at Admiral, Md.—have already received and are taking care of more than their full quota of officers and are ready to receive the number of enlisted men originally ordered there on Sept. 5.

Approximately 150,000 men were employed in the construction of the 16 cantonments up to Sept. 1; since that date the force has been gradually reduced.

A typical layout such as is required for accommodating the officers and men at a cantonment comprises, in round numbers, 1500 separate buildings, requiring approximately 30 million feet of lumber. Each cantonment requires a complete system of water-supply and sewage disposal, the piping alone for which amounts to more than 50 miles. The general warehouses, with necessary trackage, have also been provided. Where the facilities are not available in near-by cities, complete refrigerating and laundry plants have been built.

At each cantonment, up to Sept. 1, it has been necessary to complete on an average of one building per hour, or for all the cantonments an average of one building every four minutes. In the construction work over 50,000 carloads of material have been transported to and delivered at the sites.

Every National Army cantonment has required the building and installation of a transmission line for electrical current. At Camp Upton it has been necessary to take electrical power from Northport, on the north shore of Long Island, a distance of nearly 30 miles. In addition to this, the transmission line has been strengthened all the way back to Brooklyn in order that proper service can be given. In order to furnish the necessary railroad facilities, the Long Island R.R. has been required to take up rails from sidings to build the spur-tracks which are required at the cantonment.

To bring the construction materials to Camp Meade, which is some distance from an electric railroad and not on any steam railroad, it was necessary to rebuild the electric railroad to make it of sufficient strength for steam transportation. In addition, the Pennsylvania R.R. built a spur several miles in length into the cantonment site. The Government had to condemn a right-of-way.

At every cantonment approximately 4000 officers and enlisted men have already arrived.

Steamboat-Inspection Rules Amended

The Steamboat-Inspection Service has issued a circular letter, dated Aug. 24, 1917, addressed to inspectors of the service, boiler manufacturers, manufacturers of boiler plate and steamboat companies, containing amendments of the General Rules and Regulations of the Board of Supervising Inspectors, and approval of vessel equipment and boilers, as adopted by the Executive Committee of the board at a meeting held Aug. 15-22, 1917.

The restrictions relating to tensile strength required for steel boiler plates as contained in amended rules were struck out of the rules and regulations by the following amendment:

Section 5 of Rule I, General Rules and Regulations, all classes, reading as follows, was struck out:

The tensile strength determined by the tests shall be not less than 58,000 lb. per sq.in. of section nor more than 73,000 lb. per sq.in. of section, and the elongation measured in a gage length of 8 in. shall be not less than 20 per cent.

And the following paragraph was substituted therefor:

All steel plates tested shall show an elongation of at least 20 per cent. measured in a gage length of 8 inches.

The following paragraph relating to determining the area of segment of boiler head was struck out:

The area of the segment of a head to be stayed shall be that surface contained within a line drawn 3 in. from the inner circle of the head and 2 in. from the tubes or flues.

The following rule for determining the discharge capacity of a flat-seat safety valve was adopted:

The discharge capacity of a flat-seat valve shall be one and four-tenths times that allowed for a bevel-seat valve.

Owing to the excessive demands for officers of merchant vessels created by the exigencies of the war, experience and examination requirements for license as master, mate, pilot and engineer of merchant vessels, as contained in sections 20, 21, 22, 23, 26, 31 and 32 of Rule V, General Rules and Regulations, both in Great Lakes and river rules, were struck out, and the issuance of licenses to officers of vessels within the classifications referred to was left by rule to the judgment and discretion of the local inspectors, as vested in them by law, the sufficiency of the experience of an applicant for license to be determined by the local inspectors when applicant applies for examination for license.

The following resolution approving dimensions of flanges made by the Bethlehem Steel Co. was adopted:

Resolved, That the standard dimensions of cast-iron, composition and wrought-steel flanges, as prepared and submitted to the committee by the Bethlehem Steel Co. for use by the shipbuilding plants of that company, be approved as meeting the requirements of the general rules and regulations relating to flanges. Copies of the blueprints covering drawings and dimensions as submitted to the committee must be furnished by the Bethlehem Steel Co. to each supervising inspector and each board of local inspectors of the district in which the plants of the company may be located.

The action of the Executive Committee received the approval of the Secretary of Commerce on Aug. 22, 1917, under the provisions of Sections 4405 and 4491, Revised Statutes.

Copies of the circular letter, which contains the amendments in full, may be obtained on application to any board of local inspectors.

N. A. S. E. Convention at Evansville

The thirty-fifth annual convention of the National Association of Stationary Engineers was held at Evansville, Ind., Sept. 10-14, with headquarters at the Hotel Vendome. The exhibits were displayed in the New Soldiers and Sailors Coliseum, and the business sessions were held in the hall of the Liederkranz Maennerchor. The attendance was large (309 delegates having registered), the talks were interesting and the entertainment was fully up to the Evansville standard. Fourteen years ago the convention was held in this city, and its entertainment is still held in grateful remembrance by those who participated in it.

Monday, as usual, was devoted to the official registration of officers, delegates and visitors at the Coliseum, and to escorting the delegates to the headquarters. In the afternoon the annual meeting of the National Exhibitors' Association was held, and in the evening the mechanical exposition was formally opened with appropriate exercises and speeches. At 9:15 a reception was tendered the officers, delegates and visitors in Liederkranz Maennerchor Hall, which was highly enjoyed by those attending.

The opening session of the convention was held at the Memorial Coliseum, E. G. Heeger, chairman of the local committee, presiding. Promptly at 10 o'clock Tuesday morning the band struck up "America," which was sung by the entire standing assemblage. After an invocation by the Rev. William Dresel, Mayor Benjamin Bosse welcomed the delegates and visitors to Evansville in the absence of Governor Goodrich, whose serious illness prevented his presence. This welcome was fittingly responded to by National President John A. Kerley and National Vice President John A. Wickert. J. R. A. Hobson, chairman of the convention committee of the Chamber of Commerce, told of the growth and attractions of the city, and was responded to by Past National President Walter H. Damon. President Kerley then declared the convention officially opened, and after the appointment of the usual committees the meeting adjourned.

On Tuesday afternoon the first business session was held in Liederkranz Hall, and included a lecture by Eugene Graham on "How Manual Training Became Vocational Training." The Ladies' National Auxiliary and the Life and Accident Department also held their annual meetings. In the evening the ladies enjoyed a theater party, while the officers, delegates and visitors inspected the exhibit of power-plant apparatus and supplies, which filled 115 booths on the main floor of the Coliseum. The exhibits were attractively displayed, covered a wide range and afforded a valuable fund of information to the engineer.

Wednesday was manufacturers' and employers' day at the mechanical exposition. At the morning business session of the convention an interesting lecture was given, on "The One Hundredth Anniversary of George Henry Corliss, the Inventor of the Corliss Engine," by H. F. Mueller, chief engineer of the Washburn-Crosby Mills, Minneapolis, Minn. The remainder of the session was taken up by a discussion on license legislation.

In the afternoon the annual field sports and the baseball game between the teams of engineers and exhibitors were held at the Bosse Field Stadium. At the conclusion of the field sports the convention party was taken to Cook's Electric Park, where a genuine old-fashioned Kentucky barbecue was served, to which the delegates did full justice.

The convention is still in session as *Power* goes to press, and the additional happenings will be reported in next week's issue.

Electric Service at Camp Taylor

The Louisville Gas and Electric Co. is completing construction, at cost, with no percentage added, of the transmission lines and distribution system to supply Camp Zachary Taylor, the Federal Army training camp at Louisville, Ky. This camp is situated south of the city, about six miles from the Waterside power plant of the company. It is typical of the 16 similar cantonments the Government is building. Temporary service was provided by the Louisville Gas and Electric Co. by a transmission line taken off a service line reaching into the district occupied by the camp. Permanent service will be over two transmission lines, one being erected from the Waterside station, and both carrying 13,200 volts. Distribution will be by three feeder lines, running from a step-down substation reducing the primary voltage to 2300 volts three-phase 60-cycle. One feeder line supplies the pumping station serving the 1,000,000-gal elevated storage and including five 50-hp. 2200-volt motors driving centrifugal pumps, and the other feeders serving the street-lighting system and the 2000 or so structures which constitute the camp. Eighty-one transformers are installed on the building distributing system, ranging from 1 to 20 kilovolt-amperes.

Interpretations by Boiler Code Committee

Following are the interpretations of the Boiler Code Committee as approved by the Council on July 15, 1917, in Cases Nos. 162-166 inclusive:

CASE NO. 162—Inquiry: It is permissible under the A. S. M. E. Boiler Code, that safety valves bearing all the markings called for by the Code may be sold as conforming to Code requirements, when their lifting devices fail to raise the valves from their seats as required by Par. 282?

Reply: The Boiler Code requires that a safety valve be provided with a substantial lifting device and shall have the spindle so attached that the valve disk can be lifted from its seat not less than one-tenth of the nominal diameter of the valve when there is no pressure on the boiler. The Code does not specify the character of the lifting device that shall be employed.

CASE NO. 163—Inquiry: Does Par. 317 and the interpretation in Case No. 110 apply in the case of a boiler plant where duplicate feed lines are used, one of which conforms strictly with Par. 317, while in the other there are no stop valves between the check valves and the boilers?

Reply: It is the opinion of the committee that Par. 317 is intended to mean that a valve shall be placed between the boiler and a feed check in cases where a feed line is used.

CASE NO. 164—Inquiry: What is meant by the latter portion of Par. 207, which provides for greater spacing between rows of stay-bolts than indicated in Table 3? Is there not an inconsistency in the language that should be cleared up?

Reply: Par. 207 is designed to cover constructions in water-leg boilers where the portion of the sheet which comes between rows of stay-bolts is reinforced through the flanging-over of the edge of the handhole openings. It is evident that where the handhole openings are flanged to a depth of, say, twice the depth of the plate, the transverse strength is increased over what it would be should there be no such flanging. In cases of this sort the construction may be considered a beam fixed at each end, the beam to have a factor of safety of at least five.

CASE NO. 165—Inquiry: In view of Par. 274, which states that only water-heating surface, and not superheating surface, is to be considered in determining the minimum sizes of safety valves, an opinion is requested as to what portion of the tube surface of vertical tubular boilers shall be considered superheating surface.

Reply: It is the opinion of the committee that for the purpose of determining the minimum sizes of safety valves to be used in vertical fire-tube boilers, the tube surface above the center line of the upper gage-cock should be considered as superheating surface. See Par. 274.

CASE NO. 166—Inquiry: Is the maximum allowable working pressure of a locomotive boiler limited by Par. 194 of the Boiler Code, where a special flanged-ring construction is used at the base of the dome instead of flanged dome-sheet construction?

Reply: It is the opinion of the committee that the construction referred to, involving special flanged-ring construction independent of the dome sheet at the base of the dome comes under Par. 261 and must conform thereto.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Sept. 15, 1917	One Year Ago	Sept. 15, 1917	One Year Ago
Buckwheat ..	$4.98—5.20	$2.05—3.20	$7.10—7.35	$3.25—3.50
Rice	4.40—4.65	2.50—2.65	6.65—6.90	2.70—2.95
Boiler	.....	.....	.....	.....
Barley	3.90—4.15	2.20—2.35	6.15—6.40	2.35—2.60

BITUMINOUS

Prices per gross ton for Boston delivery are as follows:

	F.o.b. Mines*		Alongside Boston†	
	Sept. 15, 1917	One Year Ago	Sept. 15, 1917	One Year Ago
Clearfields ...	$4.15—4.50	$1.15—1.75	$8.00—8.35	$4.25—5.00
Cambrias and Somersets...	4.40—4.75	1.45—1.90	8.25—8.50	4.60—5.40

Pocahontas and New River, f.o.b. Hampton Roads, is $4.02—4.19, as compared with $2.85—2.90 a year ago; on cars Boston price is $9.00—9.25.

*All-rail rate to Boston is $2.60. †Water coal.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* as compared with a year ago are as follows:

ANTHRACITE

	Circular[1]		Individual[1]	
	Sept. 15, 1917	One Year Ago	Sept. 15, 1917	One Year Ago
Buckwheat ..	$4.00—4.15	$2.75	$4.50—5.10	$2.40—2.75
Rice	3.40—3.60	2.25	3.25—3.40	2.10—2.20
Barley	2.90—3.10	1.75	2.25—2.75	1.85—1.95

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	F.o.b. Sept. 15, 1917	Mine Prices One Year Ago
Bunker coal	$6.00—6.25	$4.00—4.50
Commercial	5.25—6.00*	3.00

*Based on Federal Trade Commission suggestion.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The freight rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Sept. 15, 1917	One Year Ago	Sept. 15, 1917	One Year Ago
Buckwheat ...	$2.90	$1.65	$3.80	$2.55
Rice	2.40	1.00	3.40	.....
Boiler	2.20	.90	3.30	1.80
Barley	1.90	.75	2.15	....

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Sept. 15, 1917	One Year Ago
Slack	$3.00—3.25	$0.95—1.00
Mine-run	3.00—3.25	1.35—1.45
¾-in.	3.50—3.75	1.45—1.55

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines are as follows:

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless	Springfield	Clinton and Sullivan Counties
Steam lump ..	$2.20	$2.20	$2.25	$2.20	$2.20
Lump	2.20	2.20	2.25	2.20	2.20
Egg	2.20	2.20	2.25	2.20	2.20
Nut	2.20	2.20	....	2.20	2.20
No. 1 nut....	2.20	2.20	....	2.20	2.20
No. 2 nut....	2.20	2.20	....	2.20	2.20
No. 3 nut....	2.20	2.20	....	....	....
No. 1 washed.	2.20	2.20	....	....	....
No. 2 washed.	2.20	2.20	....	....	....
Mine-run	1.95	1.95	2.00	1.95	1.95
Screenings	1.70	1.70	1.75	1.70	1.70

Hocking lump, $2.60; splint lump, $2.40.

Northern Illinois thin vein—Prepared sizes, $2.65; mine-run, $2.40; screenings, $2.15.

St. Louis—Prices pet net ton f.o.b. mines a year ago as compared with today are as follows:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Sept. 15, 1917	One Year Ago	Sept. 15, 1917	One Year Ago	Sept. 15, 1917	One Year Ago
6-in. lump..	$2.20	$1.60	$2.20*	$1.50	$2.20	$1.25
2-in. lump..	2.20	1.50	2.20*	1.40	2.20	1.10
Steam egg...	2.20	1.50	2.20*	1.40	2.20	1.10
Mine-run ...	1.95	1.25	1.95*	1.25	1.95	1.00
No. 1 nut..	2.20	1.60	2.20*	1.50	2.20	1.25
2-in. screen.	1.70	1.00	1.70*	1.00	1.70	.90
No. 5 washed	1.70	.90	1.70*	.90	1.70	.85

*Strike.

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Lump and Nut	Slack and Screenings
Big Seam	$1.90	$2.15	$1.65
Pratt, Jagger, Corona....	2.15	2.40	1.90
Black Creek, Cahaba ...	2.40	2.65	2.15

Government figures.

[1]Individual prices are the company circulars at which coal is sold to regular customers irrespective of market conditions. Circular prices are generally the same at the same periods of the year and are fixed according to a regular schedule.

PROPOSED CONSTRUCTION

Ala., Montgomery—The Montgomery Light & Traction Co. plans to erect a substation equipped with 5 rotary converters and accessories. J. M. Chumley, Engr.

Ala., Olds—The Olds Electric Co., recently organized with a capital of $20,000, plans to install an electric-light plant.

Calif., Los Angeles—City will soon receive bids for the construction of a power plant at the Ingleside Jail. Plans are being prepared by the Bureau of Architecture. Estimated cost, $15,000.

Ill., Chicago—The Commonwealth Edison Co., 72 West Adams St., plans to build a substation at 1510 West Division St. Estimated cost, $10,000.

Ill., Franklin Park—Indiana Harbor Belt R.R., Gibson, plans to build a 1-story, 38 x 62-ft. power house. Estimated cost, $20,000. O. Gersbach, Gibson, Engr.

Iowa., Humboldt—The Board of Railroad Comrs. has granted the Northern Iowa Gas & Electric Co. permission to erect transmission lines on certain roads and highways of Humboldt and Wright Cos. C. H. Smith, Supt.

Kan., Sawyer—City is considering the installation of an electric-light plant.

Ky., Flemington—The Cornettsville Coal Co. plans to build a new power plant here. J. W. Montgomery, Pres.

Ky., Whitesburg—W. C. Daniels, Monica, plans to erect a new electric power plant in the East End. Estimated cost, $25,000.

La., Westwego—Leo A. Marrero, Gretna, plans to organize a company to construct and operate an electric-light and water-works system here.

Me., Van Buren—The Public Service Comn. has authorized the Van Buren Light & Power Co. to issue $35,000 in bonds; the proceeds to be used in extensions and improvements. E. Lebrun, Supt.

Mich Colon—The Farmers & Merchants Light & Power Co., recently incorporated with $500,000 capital stock, plans to install an electric power plant on the St. Joseph River. J. L. Hawk, Pres.

Mo., St. Louis—The Union Electric Light & Power Co. will sell $1,000,000 of its preferred stock; the proceeds to be used for extensions and improvements.

N. H., Portsmouth—The Rockingham County Light & Power Co., Portsmouth, has had plans prepared by H. M. Hope, Archt., 185 Devonshire St., Boston, for a power plant. Estimated cost, $150,000.

N. M., Texico—The State Line Utilities Co., recently incorporated with $30,000 capital stock, plans to build an electric-light and power plant here.

N. Y., Geneva—The Geneva Cutlery Co. plans to build a 1-story, 60 x 120-ft. power plant. Douglas Spradge, 39 Cortland St., New York City, Engr.

N. Y., Natural Bridge—The Northern New York Utilities Inc., 137 Arsenal St., Watertown, has petitioned the Public Service Commission to issue $477,000 bonds; the proceeds to be used to complete a transmission line from here to South Edwards. J C. Wingel, Engr.

N. Y., Thiells—Frank A. Vanderlip, Pres Board of Mgrs., Letchworth Village, 7 Wall St., New York City, will soon receive bids for the construction of an addition to the central heating plant.

Ohio, Youngstown—The Republic Railway & Light Co. has secured permission to build a transmission line through the southwest section of the city.

Okla., Beaver City—City recently voted $8000 bonds to build an electric-light plant.

Okla., Miami—City plans to improve its electric-light plant and water-works system. Estimated cost. $150,000.

Ont., Lindsay—The Ontario Hydro-Electric Power Comn. plans to erect a transmission line from here to Oshawa for auxiliary service.

Ont., Toronto—The Directors of the Canadian National Exhibit are considering the construction of an auxiliary power plant.

Penn., Philadelphia—The Philadelphia Drying Machine Co., Stokely St., has had plans prepared for a 1-story power house addition.

Penn., Reading—The Metropolitan Electric Co., 16 South 5th St., has had plans prepared for the erection of a substation with 13,000 volts capacity, at 6th and Bern Sts. C. C. Long, Gen. Supt.

Que., Cedars—Cedars Rapids Hydroelectric Development Co. is having plans prepared by Unit Constr. Co., Archts., Guaranty Bldg., St. Louis, Mo., for the construction of a 130 x 600-ft. addition to its power plant.

Tenn., Mount Pleasant—The Republic Light & Power Co., Chattanooga, has acquired the property of the Mount Pleasant Electric Light Co. and plans to enlarge and improve the plant and system.

Tex., Bells—The Texas Power & Light Co., 1322 Commerce St., Dallas, plans to build a substation and erect a high-power transmission line from here to Whitewright.

Tex., Big Lake—Henry Japson has acquired a site and plans to build an electric-light plant and water-works system.

Wis., Sheboygan—The Sheboygan Couch Co., Martin and 18th Sts., is having plans prepared by T. S. Watson, Engr., Majestic Bldg., Milwaukee, for a power plant.